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Development Document for Proposed Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Petroleum Refining Point Source Category

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The report summarized EPA's review of the petroleum refining industry with respect to discharge of toxics into waters of the U.S. Information in the report included profile of industry by refining capacity and wastewater generation rate, characteristics of wastewater streams, current wastewater treatment practices, pollution abatement technologies, cost of these technologies and EPA's assessment and recommendations of proposed controls to be required for BAT, NSPS, and pretreatment standards. EPA recommendations is the reduction of pollutants discharge via flow reduction, powdered activated carbon,etc.

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NEW SOURCE PERFORMANCE STANDARDS,
and
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for the
PETROLEUM REFINING
POINT SOURCE CATEGORY

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SECTION I

EXECUTIVE SUMMARY

This development document presents the technical data base developed by EPA to support effluent limitations guidelines for the petroleum refining point source category. Technologies to achieve these limitations are defined as best available technology economically achievable (BAT), best conventional pollutant control technology (BCT), and best available demonstrated technology (BADT). This document outlines the technology options considered and the rationale for selecting each technology level. These technology levels are the basis for the proposed effluent limitations.

The rationale by which the Agency selected the technology option for each of the proposed effluent limitations guidelines is presented in Sections VIII, IX, X, and XI. Effluent limitations guidelines based on the application of BAT and BCT are to be achieved by direct dischargers by July 1, 1984. New source performance standards (NSPS) based on BADT are to be achieved by new facilities. Pretreatment standards for both existing sources (PSES) and new sources (PSNS) (based on application of BAT to those pollutants which are incompatible with a POTW) are to be achieved by indirect dischargers. These effluent limitations guidelines and standards are required by sections 301, 304, and 307 of the Clean Water Act of 1977 (P.L. 95-217).

The petroleum refining industry discharges significant quantities of toxic, conventional, and non-conventional pollutants. The Agency is proposing to control the toxic pollutants chromium (both total and hexavalent) and phenol (total 4AAP); and the conventional pollutants oil and grease, total suspended solids (TSS), and biochemical oxygen demand (BOD). Non-conventional pollutants such as ammonia, sulfite, and chemical oxygen demand (COD) are also regulated under existing BPT.

EPA is proposing BAT effluent limitations based on reduced flow through greater recycle and reuse of wastewaters; or based on the use of powdered activated carbon and/or rotating biological contractors as pretreatment before BPT. Table I-1 lists these limitations.

EPA is proposing BCT effluent limitations based on BAT technology. These limitations are listed in Table I-2.

For NSPS, EPA is proposing to prohibit the discharge of pollutants to navigable waters. This standard is based on existing industry practice at exemplary facilities and demonstrated technologies.

EPA is proposing PSNS and PSES based on removal of metals and existing PSES control technology for oil and grease and ammonia. Table I-3 lists these limitations.

EPA also is proposing separate PSES and PSNS for those refineries discharging into a POTW which has received a waiver under Section 301(h) of the Clean Water Act of 1977. Such waivers would exempt POTW's from achieving effluent limitations based on secondary treatment. These pretreatment standards are listed in Table I-4 and are based on the same technology as that for the proposed BAT guidelines. These standards, however, set explicit numerical values on the concentration of regulated pollutants. Informational mass limitations are also provided for POTWs wishing to limit total mass discharge.

EPA estimates the annual costs for the petroleum refining industry to comply with the proposed regulation to be $53.9 million.

TABLE I-1

Effluent Limitations Based on Best Available Technology
Economically Achievable (BATEA)

(Effluent Limitation= Basic Allowance
+ Cracking Adjustment
+ Asphalt and Lube Adjustment)

		Metric Units (kilograms per day)		English Units (pounds per day)	
	Pollutant or Pollutant Property	Maximum for any one day	Average of daily values for 30 consecutive days	Maximum for any one day	Average of daily values for 30 consecutive days
Basic Allowance	Phenol (4AAP)	0.0031C	0.0015C	0.0011C	0.0005C
	Total Chromium	0.0332C	0.0194C	0.0116C	0.0068C
	Hexavalent Chrom.	0.0028C	0.0013C	0.0010C	0.0005C
Cracking Adjustment	Phenol (4AAP)	0.0351K	0.0170K	0.0123K	0.0060K
	Total Chromium	0.3812K	0.2234K	0.1336K	0.0783K
	Hexavalent Chrom	0.0326K	0.0147K	0.0114K	0.0052K
Asphalt and Lube Adjustment	Phenol (4AAP)	0.0365AL	0.0177AL	0.0128AL	0.0062AL
	Total Chromium	0.3975AL	0.2332AL	0.1393AL	0.0817AL
	Hexavalent Chrom	0.0340AL	0.0154AL	0.0119AL	0.0054AL

Notes: The folowing terms are defined in metric units as thousand cubic meters per day and in English units as thousand barrels per day:

AL= sum of ashphalt and lube processes (throughput)
- Asphalt Production
- Asphalt Oxidizer
- Asphalt Emulsifying
- Hydrofining, Hydrofinishing, Lube Hydrofining
- White Oil Manufacture
- Propane Dewaxing, Propane Deasphalting, Propane Fractioning, Propane Deresining
- Duo Sol, Solvent Treating, Solvent Extraction, Duotreating, Solvent Dewaxing, Solvent Deasphalt
- Lube Vac Twr, Oil Fractionation, Batch Still (Naphtha Strip), Bright Stock Treating
- Centrifuge and Chilling
- MEK Dewaxing, Ketone Dewaxing, MEK-Toluene Dewaxing
- Deoiling (wax)
- Naphthenic Lubes Production
- SO2 Extraction
- Wax Pressing
- Wax Plant (with Neutral Separation)
- Furfural Extracting
- Clay Contacting - Percolation
- Wax Sweating
- Acid Treat
- Phenol Extraction
- Lube and Fuel Additives
- Sulfonate Plant
- MIBK
- Wax Slabbing
- Rust Preventives
- Petrolatum Oxidation
- Grease Mfg. V. Allied Products
- Misc. Blending and Packaging

K= sum of cracking processes (throughput)
- Hydrocracking
- Visbreaking
- Thermal Cracking
- Fluid Catalytic Cracking
- Moving Bed Catalytic Cracking

C= sum of crude processes (throughput)
- Atmospheric Crude Distillation
- Crude Desalting
- Vacuum Crude Distillation

TABLE I-2

Effluent Limitations Based on Best Conventional Pollutant Control Technology (BCT)

(Effluent Limitation= Basic Allowance
+ Cracking Adjustment
+ Asphalt and Lube Adjustment)

	Pollutant or Pollutant Property	Metric Units (kilograms per day)		English Units (pounds per day)	
		Maximum for any one day	Average of daily values for 30 consecutive days	Maximum for any one day	Average of daily values for 30 consecutive days
Basic Allowance	BOD5	2.195C	1.166C	0.7691C	0.4086C
	TSS	1.509C	0.9601C	0.5288C	0.3365C
	Oil and Grease	0.686C	0.366C	0.240C	0.128C
Cracking Adjustment	BOD5	25.24K	13.41K	8.845K	4.699K
	TSS	17.35K	11.04K	6.081K	3.870K
	Oil and Grease	7.89K	4.21K	2.76K	1.47K
Asphalt and Lube Adjustment	BOD5	26.33AL	13.99AL	9.229AL	4.903AL
	TSS	18.10AL	11.52AL	6.345AL	4.038AL
	Oil and Grease	8.23AL	4.39AL	2.88AL	1.54AL

Notes: Refer to notes on Table I-1 for definition of terms.

TABLE I-3

PRETREATMENT STANDARDS FOR NEW AND EXISTING SOURCES, PSES AND PSNS
(Unless the POTW has a waiver from achieving effluent
limitations based on secondary treatment)

a. The following standards apply to the total effluent flow:

milligrams per liter (mg/l)

Pollutant or Pollutant Property	Maximum for any one day
Oil and Grease	100
Ammonia (as N)	100

b. The following standard is applied to the cooling tower blowdown portion of the effluent flow or may be applied to the total effluent flow by multiplying the standard by the ratio (R) of the cooling tower blowdown flow to the total effluent flow:

milligrams per liter (mg/l)

Total Chromium	1.0

c. Informational mass limitations for the total effluent flow are as follows:

	Maximum for any one day	
Pollutant or Pollutant Property	Metric Units (kilograms per day)	English Units (pounds per day)
Oil and Grease	9.50C + 109.5K + 114.3AL	3.33C + 38.39K + 40.06AL
Ammonia (as N)	9.50C + 109.5K + 114.3AL	3.33C + 38.39K + 40.06AL
Total Chromium	Rx(0.095C + 1.095K + 1.143AL)	Rx(0.033C + 0.3839K + 0.4006AL)

Notes: R is defined in section (b) above. Refer to notes on Table I-1 for definition of terms.

TABLE I-4

PRETREATMENT STANDARDS FOR NEW AND EXISTING SOURCES, PSES AND PSNS
WHICH DISCHARGE TO POTW's WITH 304(h)WAIVERS

Pollutant or Pollutant Property	Maximum for any one day	Average of daily values for 30 consecutive days
	milligrams per liter (mg/l)	
Phenol (4AAP)	0.07	0.03
Total Chromium	0.73	0.43
Hexavalent Chromium	0.06	0.03

Informational mass limitations are as follows:

(Effluent Limitations = Basic Allowance
+ Cracking Adjustment
+ Asphalt and Lube Adjustment)

	Pollutant or Pollutant Property	Metric Units (kilograms per day)		English Units (pounds per day)	
		Maximum for any one day	Average of daily values for 30 consecutive days	Maximum for any one day	Average of daily values for 30 consecutive days
Basic Allowance	Phenol (4AAP)	0.0031C	0.0015C	0.0011C	0.0005C
	Total Chromium	0.0332C	0.0194C	0.0116C	0.0068C
	Hexavalent Chrom.	0.0028C	0.0013C	0.0010C	0.0005C
Cracking Adjustment	Phenol (4AAP)	0.0351K	0.0170K	0.0123K	0.0060K
	Total Chromium	0.3812K	0.2234K	0.1336K	0.0783K
	Hexavalent Chrom.	0.0326K	0.0147K	0.0114K	0.0052K
Asphalt and Lube Adjustment	Phenol (4AAP)	0.0365AL	0.0177AL	0.0128AL	0.0062AL
	Total Chromium	0.3975AL	0.2332AL	0.1393AL	0.0817AL
	Hexavanent Chrom.	0.0340AL	0.0154AL	0.0119AL	0.0054AL

Notes: Refer to Table I-1 notes for definition of terms.

SECTION II

INTRODUCTION

PURPOSE AND AUTHORITY

This development document details the technical basis for the Agency's proposed effluent limitations reflecting BAT, BCT, NSPS, PSES and PSNS for the petroleum refining industry. These limitations are proposed under authority of Sections 301, 304, 306, 307, 308, and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 USC 1251 et seq., as amended by the Clean Water Act of 1977, P.L. 95-217) (the "Act"). These regulations are also proposed in response to the Settlement Agreement in Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified March 9, 1979 and in response to the decision of the United States Court of Appeals in American Petroleum Institute v. EPA, 540 F.2d 1023 (10th Cir. 1976).

PRIOR EPA REGULATIONS

EPA promulgated BPT, BAT, NSPS, and PSNS for the petroleum refining point source category on May 9, 1974 (39 FR 16560, Subparts A-E). A Development Document was published in April 1974 (EPA-440/1-74-014-a). This document provided the bases for the 1974 regulations and is henceforth referred to as the 1974 Development Document. The BPT, BAT, and NSPS regulations were challenged in the courts by the American Petroleum Institute and others. Both BPT and NSPS were upheld by the court, but BAT was remanded for further consideration. Interim final PSES were promulgated on March 23, 1977 (42 FR 15684) in response to the Settlement Agreement.

OVERVIEW OF THE INDUSTRY

The petroleum refining industry is defined by Bureau of the Census Standard Industrial Classification (SIC) 2911. The raw material in this industry is petroleum material (generally, but not always, crude oil). Petroleum refineries process this raw material into a wide variety of petroleum products, including gasoline, fuel oil, jet fuel, heating oils and gases and petrochemicals. Refining includes a wide variety of physical separation and chemical reaction processes. The 1974 Development Document lists over one hundred processes used in the petroleum refining industry. Because of the diversity and complexity of the processes used and the products produced, petroleum refineries are generally characterized by the quantity of raw material processed, rather than by the quantity and types of products produced.

EPA has identified 285 petroleum refineries in the United States and its possessions. The smallest refinery can refine fifty barrels of oil per day (one barrel equals 42 gallons), while the largest can refine 665,000 barrels per day.

The U.S. refining industry processes a total of about 15 million barrels per day. However industry growth has slowed in recent years due to a number of factors including efforts to conserve petroleum supplies and competition from foreign suppliers. Growth has averaged about five percent per year and has resulted largely from additions to existing refineries rather than by construction of new ones. The ratio of growth in U.S. refining capacity by additions to existing refineries to the growth by construction of new refineries has been approximately 3.5 to 1.

Additional information can be found in the 1974 Development Document.

PRELIMINARY INDUSTRY PROFILE

One of the initial efforts on this project was to review and evaluate existing industry-wide data on such factors as refinery characteristics, production capacities, wastewater handling techniques, and wastewater characteristics. A contractor's report which summarizes the results of this effort was previously prepared and submitted to EPA (76). This report covered:

(1) Industry distribution (geographic);
(2) Intake water characteristics;
(3) Wastewater treatment techniques;
(4) Refining capacities;
(5) Water usage characteristics;
(6) Discharge permit identification;
(7) In-plant control techniques; and
(8) Cooling service characteristics.

The preliminary industry profile was based on the published literature, government reports, contacts with the industry, and contacts with various State and EPA regional offices. In order to develop new regulations, however, the Agency needed to supplement this existing data base with more recent information in the areas of wastewater characteristics and toxic pollutants.

INDUSTRY SURVEY

To acquire up-to-date information for use in the establishment of BAT guidelines for the petroleum refining category, a comprehensive questionnaire (see Appendix 1) was developed and sent to all refineries throughout the United States and its territorial possessions. This questionnaire sought information necessary to generate a profile of the petroleum refining industry. The questionnaire is henceforth referred to as the 1977 EPA Petroleum Refining Industry Survey or the "1977 survey."

In addition to updating the industry profile, The information gathered from this survey was used to aid in the selection of plants for a nationwide wastewater sampling program, and develop a flow model for the analysis of refinery wastewater production.

WASTE WATER SAMPLING PROGRAM

The Settlement Agreement cited above required the Agency to consider the potential limitations of the discharge of 65 "toxic" substances (Table II-1). The Agency undertook a sampling and analysis program to obtain information on the 65 "toxic" substances from the refinery industry. The program was designed to do the following: (a) analyze for the presence of the "toxic" substances in the plants' intake water source; (b) analyze the plants' raw wastewater to determine the net production of "toxic" substances resulting from refinery process operations; and (c) analyze the plants' final effluent for the presence of "toxic" substances and determine the removal efficiencies of BPT-type wastewater treatment systems for these substances (See Section III for details).

CONTROL AND TREATMENT TECHNOLOGY, COST ANALYSIS

Three major efforts were undertaken to identify and evaluate available control and treatment technologies:

(1) A literature search compiled the available information on the advances being made by the industry relative to wastewater handling and disposal.

(2) A review of the responses to the 1977 EPA Petroleum Refining Industry Survey determined the status of the industry with regard to in-plant source control and end-of-pipe treatment.

(3) Petroleum refineries were visited to review in detail the sources of wastewater production, as well as to review wastewater flow reduction practices, reuse, and in-plant and end-of-pipe treatment operations.

These studies established a range of control and treatment technologies available to this industry. Section VI discusses them in detail.

The study next determined the cost of the various control and treatment technologies; these are outlined in Section VII.

The results of the above described programs are presented in the subsequent sections of the document. A thorough discussion of the industry processes, the source of wastewater and the BPT end-of-pipe treatment technologies appears in the 1974 Development Document.

TABLE II-1

LIST OF TOXIC POLLUTANTS

Acenaphthene
Acrolein
Acrylonitrile
Aldrin/Dieldrin
Antimony and compounds*
Arsenic and compounds
Asbestos
Benzene
Benzidine
Beryllium and compounds
Cadmium and compounds
Carbon tetrachloride
Chlordane (technical mixture and metabolites)
Chlorinated benzenes (other than dichlorobenzenes)
Chlorinated ethanes (including 1,2-dichloroethane, 1,1,1-trichloroethane, and hexachloroethane)
Chloroalkyl ethers (Chloromethyl, chloroethyl, and mixed ethers)
Chlorinated naphthalene
Chlorinated Phenols (other than those listed elsewhere; includes trichlorophenols and chlorinated cresols)
Chloroform
2-chlorophenol
Chromium and compounds
Copper and compounds
Cyanides
DDT and metabolites
Dichlorobenzenes (1,2-,1,3-, and 1,4-dichlorobenzenes)
Dichlorobenzidene
Dichloroethylenes (1,1-and 1,2-dichloroethylene)
2,4-dichlorophenol
Dichloropropane and dichloropropene
2,4-dimethylphenol
Dinitrotoluene
Diphenylhdrazine
Endosulfan and metabolites
Endrin and metabolites
Ethylbenzene
Fluoranthene
Haloethers (other than those listed elsewhere; includes chlorophenylphenyl ethers, bromophenylphenyl ether, bis(dischloroisopropyl) ether, bis-(chloroethoxy) methane and polychlorinated diphenyly ethers)
Halomethanes (other than those listed eleswhere; includes methylene chloride methylchloride, methylbromide, bromoform, dichlorobromomethane,trichlororfluoromethane, dichlorodifluoromethane)
Heptachlor and metabolites
Hexachlorobutadiene

TABLE II-1 (Continued)

Hexachlorocyclohexane (all isomers)
Hexachlorocyclopentadiene
Isophorone
Lead and compounds
Mercury and compounds
Naphthalene
Nickel and compounds
Nitrobenzene
Nitrophenols (Including 2,4-dinitrophenol, dinitrocresol)
Nitrosamines
Pentachlorophenol
Phenol
Phthalate esters
Polychlorinated biphenyls (PCBs)
Polynuclear aromatic hydrocarbons (Including benzanthracenes, benzopyrenes, benzofluoranthene, chrysenes, dibenzanthracenes, and indenopyrenes)
Selenium and compounds
Silver and compounds
2,3,7,8,- Tetrachlorodibenzo-p-dioxin (TCDD)
Tetrachlorcethylene
Thallium and compounds
Toluene
Toxaphene
Trichloroethylene
Vinyl chloride
Zinc and compounds

* As used throughout this table the term "compounds" shall include organic and inorganic compounds.

SECTION III

WASTE CHARACTERIZATION

GENERAL

The Agency had considerable data available characterizing the discharges of "traditional" pollutant parameters (BOD, COD, TSS, NH3, sulfide, oil and grease, etc.). These parameters have been measured in wastewaters for years (1,3,8). With few exceptions, however, data on the 65 pollutants or classes of pollutants (Table II-1) are almost non-existent.

The Agency conducted a sampling program to determine the presence and concentrations of the 65 toxic substances in refinery wastewater and the effectiveness of candidate treatment technologies to reduce discharges of toxic pollutants. The list of 65 toxic pollutants and classes of pollutants potentially includes thousands of specific pollutants. The Agency has selected 129 specific toxic pollutants (Table III-1) for analysis in this rulemaking.

The Agency also requested data from the industry ("1977 survey") on: (1) toxic pollutants purchased, manufactured, and analyzed in wastewater; (2) treatability data on toxic pollutants; and (3) wastewater flow from each of the refinery processes. Measuring concentrations of these pollutants is difficult, requires very expensive equipment, and requires highly qualified operators.

1977 EPA PETROLEUM REFINING INDUSTRY SURVEY

To acquire the up-to-date information needed to establish effluent guidelines for the petroleum refining category, EPA developed a comprehensive questionnaire for all refineries throughout the United States and its territorial possessions. This survey was made under section 308 of the Clean Water Act. The questionnaire is referred to as the 1977 EPA Petroleum Refining Industry Survey or the "1977 Survey." More detailed information also was requested of the industry in a subsequent mailing, referred to as the "Supplemental Flow Question" (See Appendix 1). Finally, because of extensive industry comments on the accuracy of the data collected, the Agency made a third mailing to verify the reported data--this mailing is referred to as the "Verification Report."

The information from this survey was combined with existing information to develop an industry profile, including number of plants, their size, geographic location, and manufacturing processes and the wastewater generation, treatment, and discharge methods at refining facilities. Questionnaire data also aided in the final selection of plants for wastewater sampling. Flow data from the questionnaire were used to develop a flow model for the analysis of refinery wastewater production. Another objective of the survey was to obtain information identifying the use or generation of 123 toxic pollutants and determining the availability of plant data on the effectiveness of their removal. Since the initial questionnaire survey,, the list of toxic pollutants has been revised from 123 to the present list of 129 specific substances.

Survey Data Related to Wastewater Characterization

Toxic pollutant data contained in the 1977 survey have been summarized. The following toxic pollutants were not included in the survey because they were added to the toxic pollutant list after the questionnaire mailing in February of 1977:

di-n-octyl phthalate
PCB 1221 (Arochlor 1221)
PCB 1232 (Arochlor 1232)
PCB 1248 (Arochlor 1248)
PCB 1260 (Arochlor 1260)
PCB 1016 (Arochlor 1016)

Table III-2 lists the number of refineries with positive responses regarding priority pollutants as:

a. Chemicals purchased as raw or intermediate materials; and

b. Chemicals manufactured as a final or intermediate material;

Seventy-one toxic pollutants were listed as being purchased as a raw or intermediate materials; 19 of these toxic pollutants were individual purchases by single refineries, while at least ten percent of the refineries purchased the following toxic pollutants:

benzene
carbon tetrachloride
1,1,1-trichloroethane
phenol
toluene
zinc and compounds
chromium and compounds
copper and compounds
lead and compounds

Zinc and chromium were purchased by 28 percent of the refineries, while lead was purchased by nearly 48 percent of the plants.

Forty-five toxic pollutants were manufactured as final or intermediate materials; 15 of these toxic pollutants were manufactured at single refineries, while benzene, ethylbenzene, phenol, and toluene were manufactured by at least ten percent of the refineries. Eight percent of the refineries manufacture cyanides; greater than 20 percent of the refineries manufacture benzene/toluene.

Table III-3 presents industry data on wastewater generated in 1976 and the discharge flows reported in the NPDES permit in 1976 on a plant by plant basis. Also included for comparison is the calculated flow for each plant, which was determined on the basis of the process data supplied for each plant and the original 1974 EPA flow model (see Section IV for details).

The 1977 survey has also requested data on daily average discharge concentration of priority pollutants for the month of December in 1975 and 1976. These data are summarized in Table III-4. Pollutants for which data were reported include cadmium, copper, cyanide, lead, mercury, zinc, arsenic, nickel, silver, selenium, and free cyanide. Phenol and chromium are limited by existing BPT regulations, and therefore do not appear in the table. About ten percent of the industry currently has effluent limits for zinc and cyanide.

WASTEWATER SAMPLING PROGRAM RESULTS

EPA determined the presence and magnitude of the 129 specific toxic pollutants in petroleum refining wastewaters in a sampling and analysis program involving 23 refineries and two POTWs. The sampled plants were selected to be representative of the manufacturing processes, the prevalent mix of production among plants, and the current treatment technology in the industry. Seventeen plants were direct dischargers and six were indirect dischargers.

Sampling visits were made to correspond to three consecutive days of plant operation. Raw wastewater was sampled prior to biological treatment; treated effluent was sampled subsequent to biological treatment. In some instances, samples were taken after polishing (i.e., polishing pond, sand filter). The intake water also was sampled to determine the presence of toxic pollutants prior to contamination by refining processes.

Samples for conventional, nonconventional and toxic pollutants came 24-hour composite samples. The laboratory combined aliquots from these samples in equal portions to obtain the 72-hour composites for toxic pollutant analysis (acid and base-neutral extractible organics, pesticides, and metals). Grab samples were taken in specially prepared vials for volatile (purgeable) organics, total phenols and cyanide. Prior to the plant visits, sample containers were carefully washed and prepared by specific methods, depending upon the type of sample to be taken. Samples were kept on ice prior to express shipment in insulated containers.

The analyses for toxic pollutants were performed according to groups of chemicals and associated analytical schemes. Organic toxic pollutants included volatile (purgeable), base-neutral and acid (extractable) pollutants, total phenols, and pesticides. Inorganic toxic pollutants included heavy metals, cyanide, and asbestos.

The primary method used to screen and verify the volatiles, base-neutral, and acid organics was gas chromatography with confirmation and quantification of all priority pollutants by mass spectrometry (GC/MS). Total phenols were analyzed by the 4-AAP method. GC was employed for analysis of pesticides with limited MS confirmation. Toxic heavy metals were analyzed by atomic adsorption spectrometry (AAS), with flame or graphite furnace atomization following appropriate digestion of the sample. Duplicate samples were analyzed using plasma emission spectrometry after appropriate digestion. Samples were analyzed for cyanides by a colorimetric method, with sulfide previously removed by distillation. Analysis for asbestos was accomplished by microscopy and fiber presence reported as chrysotile fiber count. Analyses for conventional pollutants (BOD_5, TSS, pH, and Oil and Grease) and nonconventional pollutants (TOC and COD) were accomplished using "Methods for Chemical Analysis of Water and Wastes," (EPA 625/6-74-003) and amendments.

Three sampling programs were conducted in this project: (1) the Robert S. Kerr Environmental Research Laboratory (RSKERL) Sampling Program (12 refineries); (2) the Burns and Roe (B&R) Supplemental Sampling Program (5 refineries) and (3) the Burns and Roe Indirect Discharge Sampling Program (6 refineries and two POTW's). In addition, eight refineries were sampled by the U.S. EPA regional surveillance and analysis field teams in conjunction with their routine S&A work. This sampling was performed after the RSKERL and Burns and Roe sampling program and generally followed the same screening procedure. Analytical data from refineries 1, 83, 131, 132, 133, 134, 157 and 181 for S&A sampling of raw water supply, raw wastewater, final effluent, and some in-plant sampling, are included in Appendix 2 of this report.

RSKERL and B & R Sampling Program

The RSKERL and B & R sampling program was designed to do the following: (a) analyze for the presence of the 129 toxic pollutants in the plants' intake water source; (b) analyze the plants' raw wastewater to determine the net production of priority pollutants resulting from refinery process operations; and (c) analyze the plants' final effluent for the presence of toxic pollutants and measure the effectiveness of in-place treatment in removing toxic pollutants.

The program was undertaken in two parts: The RSKERL sampling included 12 refineries selected according to the following criteria:

a. They should be meeting the July 1, 1977, effluent limitations specified in the NPDES permit;

b. They should have single discharge points for their treated process wastewater.

c. Their process types, geographic locations, and wastewater treatments were representative of the industry and provided the broadest coverage on a national basis.

The selection procedures is detailed in two Burns and Roe reports (S1 - Analysis of Self Reporting Data From Refineries to Determine Compliance with July 1, 1977, Effluent Limitations (78) and S2 - Selection of Refineries for RSKERL Sampling Program (79)).

The RSKERL program involved two segments: segment A sampled six of the selected plants; segment B covered the remaining six refineries and also tested the toxic removal efficiency of carbon adsorption treatment on a pilot scale. Granular activated carbon was tested at six plants and powdered activated carbon was tested in four of the same six plants. These pilot test results are included in section V of this report.

The B & R program was initiated to supplement the RSKERL sampling and studied five refineries. This program did not include any pilot carbon testing.

Tables III-5 through III-10 present the analytical results from the RSKERL and B & R sampling programs. The traditional parameters analyzed include BOD5, COD, TOC, TSS, oil and grease, ammonia, sulfides, hexavalent chromium, and pH. Each of the three, consecutive 24-hour, composites collected at each sampling location in a given refinery was tested for the traditional parameters other than oil and grease. Grab samples collected at the end of each sample day were used for the oil and grease analyses. Table IV-5 summarizes the traditional pollutant analytical results reported for all 17 refineries.

Sources of asbestos in the petroleum refining industry are, in all probability, the same as in other point source categories: (a) insulation materials that have deteriorated; and (b) residues from the brake linings of equipment and vehicles used in the processing areas. Because EPA believes that these may not be significant sources of asbestos, and because of the expense of asbestos analyses and the liklihood of similar data within other point source categories, samples from only four petroleum refineries were analyzed.

Since asbestos contributions to wastewater streams could be affected by rainfall (i.e., runoff could wash fragmented insulation into the sewer), EPA sampled two refineries for asbestos during dry weather condition and two during or shortly after a significant rainfall. The Agency sampled refinereies in which treatment detention time did not affect significantly the rainfall criteria. Composites of three daily grab samples from Refineries I, L, M and P were analyzed for asbestos. Rainfall data also were collected and analyzed. The analytical method for asbestos includes the use of an electron microscope for verification of each fiber and confirmed by nondispersive x-ray fluorescence. All of the samples had low concentrations of suspended solids, and an absence of vegetal and biological debris.

Abestos was not detected in the intake or final effluent from the four refineries. Asbestiform mineral fibers of 3.4 million fibers per liter were observed and verified in only one sample, the API separator effluent from Refinery L. It had been raining during the time that samples were collected at Refinery L.

During this RSKERL/Burns and Roe sampling program, the American Petroleum Institute and some individual plants were provided with replicate samples for their own analysis. The results of these analyses are presented in Appendix 3 of this report.

Pretreatment Sampling Program

Burns and Roe conducted a sampling program at two Los Angeles county Sanitation District municipal treatment plants and refineries which contribute wastewater to these plants. A three day sampling period, similar to the RSKERL and Burns and Roe sampling program, was utilized at the final effluent points of six refineries, and at various points in the municipal treatment plants. Analytical results of this sampling program are presented in Tables III-11 thru III-20.

TABLE III-1

RECOMMENDED LIST OF PRIORITY POLLUTANTS

* No.	Compound	No.	Compound
1B	acenaphthene	33V	1,2-dichloropropylene
2V	acrolein	34A	2,4-dimethylphenol
3V	acrylonitrile	35B	2,4-dinitrotoluene
4V	benzene	36B	2,6-dinitrotoluene
5B	benzidine	37B	1,2-diphenylhydrazine
6V	carbon tetrachloride	38V	ethylbenzene
7V	chlorobenzene	39B	fluoranthene
8B	1,2,4,-trichlorobenzene	40B	4-chlorophenyl phenyl ether
9B	hexachlorobenzene	41B	4-bromophenyl phenyl ether
10V	1,2-dichloroethane	42B	bis(2-chloroisopropyl) ether
11V	1,1,1-trichloroethane	43B	bis(2-chloroethoxy) methane
12B	hexachloroethane	44V	methylene chloride
13V	1,1-dichloroethane	45V	methyl chloride
14V	1,1,2-trichloroethane	46V	methyl bromide
15V	1,1,2,2-tetrachloroethane	47V	bromoform
16V	chloroethane	48V	dichlorobromomethane
17B	bis(chloromethyl) ether	49V	trichlorofluoromethane
18B	bis(2-chloroethyl) ether	50V	dichlorodifluoromethane
19V	2-chloroethylvinyl ether	51V	chlorodibromomethane
20B	2-chloronaphthalene	52B	hexachlorobutadiene
21A	2,4,6-trichlorophenol	53B	hexachlorocyclopentadiene
22A	parachlorometa cresol	54B	isophorone
23V	chloroform	55B	naphthalene
24A	2-chlorophenol	56B	nitrobenzene
25B	1,2-dichlorobenzene	57A	2-nitrophenol
26B	1,3-dichlorobenzene	58A	4-nitrophenol
27B	1,4-dichlorobenzene	59A	2,4-dinitrophenol
28B	3,3'-dichlorobenzidine	60A	4,6-dinitro-o-cresol
29V	1,1-dichloroethylene	61B	N-nitrosodimethylamine
30V	1,2-trans-dichloroethylene	62B	N-nitrosodiphenylamine
31A	2,4-dichlorophenol	63B	N-nitrosodi-n-propylamine
32V	1,2-dichloropropane	64A	pentachlorophenol

TABLE III-1 (Cont.)

No.	Compound
65A	phenol
66B	bis(2-ethylhexyl) phthalate
67B	butyl benzyl phthalate
68B	di-n-butyl phthalate
69B	di-n-octyl phthalate
70B	diethyl phthalate
71B	dimethyl phthalate
72B	benzo(a)anthracene
73B	benzo(a)pyrene
74B	3,4-benzofluoranthene
75B	benzo(k)fluoranthene
76B	chrysene
77B	acenaphthylene
78B	anthracene
79B	benzo(ghi)perylene
80B	fluorene
81B	phenanthrene
82B	dibenzo(a,h)anthracene
83B	ideno(1,2,3-cd)pyrene
84B	pyrene
85V	tetrachloroethylene
86V	toluene
87V	trichloroethylene
88V	vinyl chloride
89P	aldrin
90P	dieldrin
91P	chlordane
92P	4,4'-DDT
93P	4,4'-DDE
94P	4,4'-DDD
95P	a-endosulfan-Alpha
96P	b-endosulfan-Beta
97P	endosulfan sulfate
98P	endrin
99P	endrin aldehyde
100P	heptachlor
101P	heptachlor epoxide

No.	Compound
102P	a-BHC-Alpha
103P	b-BHC-Beta
104P	r-BHC-Gamma
105P	g-BHC-Delta
106P	PCB-1242
107P	PCB-1254
108P	PCB-1221
109P	PCB-1232
110P	PCB-1248
111P	PCB-1260
112P	PCB-1016
113P	toxaphene
114M	antimony(total)
115M	arsenic(total)
116	asbestos(fibrous)
117M	beryllium(total)
118M	cadmium(total)
119M	chromium(total)
120M	copper(total)
121M	cyanide(total)
122M	lead(total)
123M	mercury(total)
124M	nickel(total)
125M	selenium(total)
126M	silver(total)
127M	thallium(total)
128M	zinc(total)
129B	2,3,7,8-tetrachloro-dibenzo-p-dioxin(TCDD)

* V - volatile organics
A - acid extractables
B - base/neutral extractables
P - pesticides
M - metals

TABLE III-2

Summary of Responses to Portfolio B of 1977 Survey
(Number of Refineries)

(253 respondents summarized)

Priority Pollutants	(1) Chemicals purchased as a raw or intermediate material	(2) Chemicals manufactured as a final or intermediate material	(3) Chemicals for which analyses have been performed in wastewater
acenaphthene	9	8	1
acrolein	1	0	0
acrylonitrile	2	0	1
benzene	42	62	6
carbon tetrachloride	30	2	3
chlorobenzene	0	0	1
1,2-dichloroethane	6	0	1
1,1,1-trichloroethane	26	2	2
hexachloroethane	1	0	1
1,1-dichloroethane	2	0	1
1,1,2-trichloroethane	4	0	1
1,1,2,2-tetrachloroethane	1	0	1
chloroethane	1	0	1
2,4,6-trichlorophenol	1	0	0
chloroform	9	0	1
2-chlorophenol	2	0	1
1,2-dichlorobenzene	2	0	2
1,3-dichlorobenzene	0	0	1
dieldrin	1	2	0
benzidine	0	4	0
p-chloro-m-cresol	0	0	1

TABLE III-2 (Continued)

Summary of Responses to Portfolio B of 1977 Survey
(Number of Refineries)

(253 respondents summarized)

Priority Pollutants	(1) Chemicals purchased as a raw or intermediate material	(2) Chemicals manufactured as a final or intermediate material	(3) Chemicals for which analyses have been performed in wastewater
1,4-dichlorobenzene	0	0	1
1,1-dichloroethylene	6	0	1
1,2-trans-dichloroethylene	2	0	0
2,4-dichlorophenol	0	0	2
1,2-dichloropropane	6	0	1
1,3-dichloropropylene	3	0	1
2,4-dimethylphenol	9	11	14
asbestos	18	0	1
ethylbenzene	24	31	3
fluoranthene	13	11	1
methylene chloride	2	0	0
methyl bromide	1	0	0
trichlorofluoromethane	12	0	0
dichlorodifluoromethane	9	0	0
naphthalene	18	18	2
nitrobenzene	1	0	0
pentachlorophenol	10	1	1
4-nitrophenol	1	0	0
methyl chloride	1	0	0
isophorone	0	1	1

TABLE III-2 (continued)

Summary of Responses to Portfolio B of 1977 Survey (Number of Refineries)

(253 respondents summarized)

Priority Pollutants	(1) Chemicals purchased as a raw or intermediate material	(2) Chemicals manufactured as a final or intermediate material	(3) Chemicals for which analyses have been performed in wastewater
phenol	32	32	154
bis(2-ethylhexyl) phthalate	1	1	0
butyl benzyl phthalate	1	1	0
di-n-butyl phthalate	1	1	0
diethyl phthalate	1	1	0
dimethyl phthalate	1	1	0
PCB-1242	1	0	0
PCB-1254	1	0	0
1,2-benzanthracene	14	12	1
benzo (a)pyrene	14	12	1
3,4-benzofluoranthene	10	12	1
11,12-benzofluoranthene	10	12	1
chrysene	16	14	1
acenaphthylene	11	12	1
anthracene	16	14	2
1,12-benzoperylene	14	12	1
fluorene	10	12	3
phenanthrene	16	14	2

TABLE III-2 (continued)

Summary of Responses to Portfolio B of 1977 Survey
(Number of Refineries)

(253 respondents summarized)

Priority Pollutants	(1) Chemicals purchased as a raw or intermediate material	(2) Chemicals manufactured as a final or intermediate material	(3) Chemicals for which analyses have been performed in wastewater
1,2:5,6-dibenzanthracene	11	12	1
indeno (1,2,3-C,D)pyrene	11	12	1
pyrene	16	14	2
2,3,7,8-tetrachlorodibenzo-p-dioxin	0	1	0
tetrachloroethylene	2	1	2
toluene	53	53	7
trichloroethylene	12	0	2
vinyl chloride	0	0	1
antimony and compounds	8	1	15
arsenic and compounds	6	1	65
zinc and compounds	71	6	98
beryllium	0	0	16
cadmium and compounds	4	0	75
chromium and compounds	80	5	156
copper and compounds	26	1	87
cyanides	1	20	94
lead and compounds	121	9	94
mercury and compounds	5	0	63

TABLE III-2 (continued)

Summary of Responses to Portfolio B of 1977 Survey (Number of Refineries)

(253 respondents summarized)

Priority Pollutants	(1) Chemicals purchased as a raw or intermediate material	(2) Chemicals manufactured as a final or intermediate material	(3) Chemicals for which analyses have been performed in wastewater
nickel and compounds	21	6	71
selenium and compounds	2	1	27
silver and compounds	6	1	36
thallium and compounds	1	1	5

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
1	8	35	8
2	3	13	3
3	13	89	13
4	.04	13	0
6	4	30	4
7	4	13	4
8	4	39	0
9	11	23	11
10	14	78	14
11	35	58	35
12	192	89	21
13	31	40	0
14	7	14	0
15	5	20	0
16	9	32	0
17	7	47	0
18	14	47	0
19	3	78	.06
20	22	47	22
21	4	13	0
22	13	43	0
23	4	13	0

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
24	7	15	7
25	10	43	0
26	9	16	0
29	37	56	0
30	12	13	12
31	.6	22	0
32	70	51	40
33	10	20	0
35	15	13	0
36	3	40	0
37	31	79	31
38	37	39	0
39	11	13	0
40	34	27	34
41	36	55	36
42	5	13	0
43	62	53	46
44	25	30	0
45	43	47	0
46	22	81	22

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
48	112	24	0
49	5	28	5
50	10	24	5
51	67	49	67
52	107	78	107
53	19	47	19
54	6	33	6
55	2	14	0
56	29	24	29
57	129	32	129
58	26	25	0
59	24	33	24
60	11	31	13
61	17	38	17
62	19	89	19
63	36	33	36
64	68	43	68
65	29	35	29
66	UNKNOWN	13	0
67	65	58	64
68	41	27	41

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
70	17	13	17
71	13	22	13
72	23	51	23
73	25	23	0
74	10	41	10
76	56	75	56
77	12	20	12
78	26	23	0
79	UNKNOWN	14	0
80	5	34	5
81	22	28	22
82	281	13	0
83	35	51	35
84	21	21	21
85	25	38	25
86	15	33	0
87	18	13	18
88	6	13	6
89	22	34	22
90	25	89	18
91	3	13	3

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
92	44	89	42
93	15	13	8
94	23	25	23
95	29	13	0
96	25	54	22
97	3	19	3
98	13	31	12
99	3	20	3
100	9	13	9
102	32	17	32
103	2	13	2
104	30	41	24
105	30	12	28
106	18	38	14
107	4	40	4
108	19	89	19
109	21	12	21
110	7	13	7
111	24	43	0
112	36	13	36

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
113	13	25	12
114	12	20	12
115	27	56	27
116	21	49	21
117	36	30	36
118	9	88	7
119	16	78	13
120	38	89	35
121	17	27	17
122	72	47	72
124	14	36	14
125	9	28	9
126	163	36	54
127	30	43	30
128	4	13	0
129	23	16	23
130	31	20	0
131	24	38	24
132	35	41	35
133	86	60	86
134	45	32	45
135	0	13	0

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
136	11	13	0
137	2	13	0
138	26	17	0
139	2	13	0
140	9	29	0
141	.09	13	0
142	26	42	26
143	38	43	38
144	14	20	4
145	5	13	0
146	24	14	24
147	9	49	9
148	10	43	0
149	27	23	27
150	24	22	24
151	25	41	25
152	83	40	83
153	35	29	19
154	209	89	23
155	13	35	7
156	20	29	17
157	16	35	16
158	13	26	13

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
159	15	20	14
160	8	17	8
161	14	16	8
162	30	85	27
163	20	26	20
164	6	13	0
165	5	47	5
166	16	89	0
167	33	31	31
168	19	31	18
169	56	31	55
172	98	66	98
173	224	89	224
174	109	89	109
175	81	67	78
176	14	31	11
177	134	89	134
179	12	45	12
180	46	53	46
181	47	37	4
182	27	37	0

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
183	13	16	13
184	22	47	22
185	11	24	0
186	13	24	13
187	16	43	0
188	27	30	0
189	3	13	3
190	5	13	5
191	9	43	0
192	201	13	0
193	.2	13	0
194	43	60	47
195	1	13	0
196	61	50	61
197	16	13	16
199	24	13	24
200	24	36	0
201	14	20	14
202	1	13	0
203	44	47	0
204	34	29	34
205	24	23	24
206	3	13	0

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
207	2	13	0
208	18	41	18
209	8	20	0
210	3	13	.2
211	7	21	7
212	13	20	13
213	4	13	4
214	DATA NOT SUBMITTED	-	0
215	DATA NOT SUBMITTED	-	0
216	54	45	35
218	.1	13	0
219	17	28	17
220	2	85	0
221	29	17	29
222	42	10	42
224	12	14	0
225	35	36	0
226	8	13	8
227	37	25	16
228	16	14	0
229	3	27	0
230	30	40	30

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
231	169	13	169
232	22	29	22
233	10	33	10
234	18	53	18
235	21	36	21
236	28	33	28
237	10	89	10
238	27	20	27
239	10	19	10
240	130	89	130
241	76	89	50
242	147	89	147
243	6	18	6
244	54	28	0
245	26	29	0
246	53	41	0
247	12	14	0
248	.01	13	0
249	21	16	0
250	0	13	0
251	0	13	0
252	21	20	21
253	DATA NOT SUBMITTED	-	0

TABLE III-3

PETROLEUM REFINING WASTEWATER FLOW DATA

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Calculated BPT Flow (gal/bbl)	NPDES Discharge in 1976 (gal/bbl)
254	.7	89	0
255	4	13	4
256	11	17	11
257	16	31	16
258	15	110	15
259	4	19	4
260	13	89	13
261	14	14	14
264	5	13	0
265	12	25	12
266	25	13	25
278	0	13	0
291	12	13	0
292	UNKNOWN	13	UNKNOWN
295	129	13	129
296	0	13	0
298	1	13	0
302	.04	13	0
303	0	13	0
305	4	13	0
307	0	13	0
308	0	13	0
309	18	18	11
310	.9	13	0

TABLE III-4

Priority Pollutant Discharge Monitoring Report
Data Reported in the 1977 Survey

	Refinery Number	December 1975 DMR Daily Average		December 1976 DMR Daily Average	
		(mg/l)	(lb/day)	(mg/l)	lb/day)
Cadmium	018	-	-	-	-
	025	-	-	-	-
	071	0.035	-	< 0.015	-
	182	ND	ND	ND	ND
	029	-	-	-	-
	038	-	-	-	-
	043	-	-	-	-
	045	-	-	-	-
Copper	013	ND	ND	ND	ND
	018	-	-	-	-
	096	-	6	-	2.0
	153	0.072	0.63	0.042	0.85
	182	ND	ND	-	31.3(a)
Cyanide	018	-	-	-	-
	057	-	-	-	-
	059	0.005	-	0.036	-
	060	0.008	-	0.129	-
	065	0.037	-	0.006	-
	068	-	0.01	-	0.64
	071	0.086	-	0.036	-
	073	0.0	-	0.0	-
	151	0.30	10.4	0.64	23
	153	0.03	0.49	0.007	0.13
	029	-	-	-	-
	038	-	-	-	-
	043	-	-	-	-
	045	-	-	-	-
	061	0.081	-	0.047	-
	062	0.03	-	0.03	-
	063	-	-	-	-
	064	-	-	< 0.02	-
	208	-	2.75	-	22.2
Lead	013	ND	ND	ND	ND
	057	-	-	-	-
	096	-	4	-	4.0
	153	0.067	0.59	0.018	0.36
	182	ND	ND	ND	ND
	029	-	-	-	-
	038	-	-	-	-
	043	-	-	-	-
	045	-	-	-	-
	061	0.052	-	-	0.03
	062	0.017	-	0.008	-
	208	-	3.35	-	7.9

TABLE III-4 (Cont.)

	Refinery Number	December 1975 DMR Daily Average		December 1976 DMR Daily Average	
		(mg/l)	(lb/day)	(mg/l)	lb/day)
Mercury					
	058	-	-	-	-
	096	-	-	-	-
	182	-	0.056	ND	ND
	029	-	-	-	-
	038	-	-	-	-
	043	-	-	-	-
	045	-	-	-	-
	061	-	-	-	-
Zinc					
	013	ND	ND	ND	ND
	020	-	1.5	-	0.11
	024	-	0.30	-	0.10
	032	-	1.0	-	5.1
	041	-	18	-	22
	050	0.59	-	1.1	-
	057	-	-	-	-
	060	0.15	-	0.14	-
	065	0.23	-	0.04	-
	093	-	0.0024	-	0.0011
	096	-	12	-	8
	108	-	0.32	-	0.22
	114	0.43	-	0.31	-
	153	0.131	1.1	0.193	3.96
	182	-	31.2	-	27.9[a]
	242	-	0.32	-	0.22
	029	-	-	-	-
	037	-	(0.98 kg/day)	-	(0.45 kg/day)
	038	-	-	-	-
	043	-	-	-	-
	045	-	-	-	-
	061	-	-	-	-
	062	<0.1	-	0.1	-
	208	-	7.35	-	10.5
	295	-	1.6	-	0.57
Arsenic					
	013	ND	ND	ND	ND
	182	ND	ND	ND	ND
	242	-	0.53	-	0.20
	029	-	-	-	-
	038	-	-	-	-
	043	-	-	-	-
	045	-	-	-	-
	208	-	2.16	-	0.78

TABLE III-4 (Cont.)

	Refinery Number	December 1975 DMR Daily Average (mg/l)	December 1975 DMR Daily Average (lb/day)	December 1976 DMR Daily Average (mg/l)	December 1976 DMR Daily Average lb/day)
Nickel					
	182	ND	ND	ND	ND
	029	-	-	-	-
	038	-	-	-	-
	043	-	-	-	-
	045	-	-	-	-
Silver					
	182	ND	ND	ND	ND
	029	-	-	-	-
Selenium					
	182	-	0.81	ND	ND
Cyanide (Free)					
	045	-	-	-	-
	153	-	-	0.002	0.03

NOTES: ND - Not Detectable
(a) - Data are maximum values.

TABLE III-5

Analytical Results for Traditional Parameters for the RSKERL and B&R Sampling Program

	Concentration (mg/l)											
Sample - Day	BOD-1	BOD-2	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH	Flow (MGD)
Refinery A												
Intake - 1	L2	L2		4	1	5	L1.0	L.02	L.1		7.6	
Intake - 2	L1	L1		4	2	4	11	L.02	L.1		9.0	
Intake - 3	2	4		8	2	L1	1.0	L.02	.2		8.8	
Separator effluent - 1	20	24		130	36	490	13	.09	9.0		8.6	
Separator effluent - 2	20	18		91	25	390	11	.03	6.9		8.5	
Separator effluent - 3	25	30		99	26	260	11	.05	8.5		9.0	
Final effluent - 1	L2		L2	36	11	44	16	.04	.2		6.9	.433
Final effluent - 2	L2		L2	40	11	30	11	L.02	.2		7.4	.427
Final effluent - 3	3		2	28	11	42	9.0	L.02	.4		7.0	.432
Refinery B												
Intake - 1	L3	L3		9	13	9	L1.0	L.02	.2	19	8.2	3.91
Intake - 2	L3	L3		9	25	13	L1.0	.02	.2	7	8.1	3.86
Intake - 3	2	L3		9	18	11	L1.0	L.02	.4	6	8.3	4.12
DAF effluent - 1	130	140		420	100	38	8.4	L.02	.6	33	6.2	1.78
DAF effluent - 2	170	110		440	110	50	7.3	.10	1.0	18	8.6	1.81
DAF effluent - 3	270	220		500	110	38	6.7	L.02	1.2	11	9.5	1.81
Final effluent - 1	15		14	150	47	22	18	L.02	.5	53	7.2	1.69
Final effluent - 2	9		7	120	39	24	16	L.02	.5	24	7.6	2.07
Final effluent - 3	30		7	120	43	20	18	L.02	.6	15	7.4	1.48
Refinery C												
Intake - 1	2			1	12	L1	L1.0	L.02	L.5	8	7.6	
Intake - 2	L3			1	8	L1	L1.0	L.02	L.5	10	7.8	
Intake - 3	2			2	5	L1	L1.0	L.02	.3	4	7.4	
Separator effluent - 1	150		110	380	88	22	52	.05	L.5	150	8.6	
Separator effluent - 2	160		120	370	75	36	50	L.02	3.8	100	9.1	
Separator effluent - 3	78		85	220	49	26	13	L.02	.3	28	8.7	
Treated effluent - 1	28			130	44	20	8.4	L.02	L.5	8	7.8	.0715
Treated effluent - 2	34			120	39	18	5.6	L.02	L.5	15	7.7	.0848
Treated effluent - 3	40			120	41	28	4.5	L.02	.2	11	7.6	.1526
Final effluent - 1	37			130	42	20	7.8	L.02	.5	7	8.0	.1787
Final effluent - 2	40			130	37	22	17	L.02	.5	11	8.1	.1411
Final effluent - 3	45			100	36	16	3.9	L.02	.4	11	7.6	.2357

Note: L - Less than
G - Greater than

BOD-1 indicates analytical method used seed from a domestic sewage treatment plant.

BOD-2 indicates analytical method used seed from refinery final effluent.

BOD-3 indicates analytical method where no seed was used.

TABLE III-5 (Continued)

Analytical Results for Traditional Parameters for the RSKERL and B&R Sampling Program

Sample - Day	BOD-1	BOD-2	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH	Flow (MGD)
	Concentration (mg/1)											
Refinery D												
Intake - 1	L5	20		20	10	24	L1.0	L.02	L.1		7.3	
Intake - 2	1	4		4	5	32	2.2	L.02	L.1		7.4	
Intake - 3	3	6		4	8	16	2.0	L.02	L.1		7.3	
DAF effluent - 1	160	L220		1000	300	60	36	L.02	15		8.9	
DAF effluent - 2	140			500	150	36	29	L.02	18		8.5	.932*
DAF effluent - 3	120	L360		390	100	32	40	L.02	15		8.6	
Final effluent - 1	50		40	820	290	64	36	L.02	1.7		7.7	
Final effluent - 2	210		62	670	220	60	42	L.02	1.1		7.7	.932*
Final effluent - 3	150		90	490	150	60	39	.03	.8		7.6	
Refinery E												
Intake - 1	3	4		43	15	14	1.0	L.02	L.1		7.7	18.00
Intake - 2	2	3		59	15	19	7.8	L.02	L.1		7.6	16.56
Intake - 3	2	3		39	15	28	7.8	L.02	L.1		7.5	18.00
DAF effluent - 1	54	56		160	48	17	13	L.02	1.8		7.3	
DAF effluent - 2	52	41		160	42	13	12	L.02	1.5		7.1	
DAF effluent - 3	45	44		150	39	16	15	L.02	1.5		7.2	
Final effluent - 1	18		18	47	10	9	35	L.02	.3		7.6	5.02
Final effluent - 2	2		L1	75	7	20	11	L.02	.5		7.5	4.59
Final effluent - 3	L1		L1	55	13	13	13	L.02	.6		7.5	4.61
Refinery F												
Intake - 1	40	50		340	96	68	1.7	L.02	1.6		8.2	1.5*
Intake - 2	40	52		350	110	68	68	.02	.9		8.1	
Intake - 3	42		35	340	97	40	63	L.02	.7		8.0	
Cooling tower blowdown-1	25	42		210	62	64	3.9	.05			7.3	0.17*
Cooling tower blowdown-2	130	G160		300	78	76	10	.09	1.0		8.1	
Cooling tower blowdown-3	47	36		350	95	80	19	.41	L.1		6.8	
Final effluent - 1	18		18	260	110	110	3.9	L.02			8.6	0.017*
Final effluent - 2	36		36	270	75	96	2.8	L.02	2.0		8.5	
Final effluent - 3	20		18	260	82	100	3.9	.03	L.1		8.6	

* Average flow during 72-hour sampling period.

TABLE III-5 (Continued)

Analytical Results for Traditional Parameters for the RSKERL and B&R Sampling Program

Sample-Day	Concentration (mg/l)											
	BOD-1	BOD-2	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH	Flow (MGD)
Refinery G												
Intake - 1	L3	L3	L3	20	12	L1	L1.0	L.02	L.1	23	7.6	3.22
Intake - 2	L3	L3		28	16	18	L1.0	L.02	.6	7	7.6	3.13
Intake - 3	L3	L3		24	8	16	L1.0	L.02	.3	8	7.7	3.20
Separator effluent - 1	240	280	260	820	240	54	20	.02	22	130	10.2	
Separator effluent - 2	250	240				252		.02	32	56	10.3	
Separator effluent - 3	260	290		860	220	112	8.0	L.02	28	110	10.6	
DAF effluent - 1	240	270	250	860	200	64	14	.02	18	190	9.9	
DAF effluent - 2	280	280		900	360	152	12	L.02	28	250	10.2	
DAF effluent - 3	220	260		1200	290	176	10	L.02	30	220	10.4	
Final effluent - 1	15		12	200	60	36	15	L.02	2.0	24	8.3	2.50
Final effluent - 2	10		L10	220	64	76	15	L.02	1.8	9	8.0	2.27
Final effluent - 3	6		L14	210	56	64	12	L.02	2.1	10	8.0	2.04
Refinery H												
Intake - 1	L2	L2		12	9	14	L1.0	L.02	.3	31	8.2	35.*
Intake - 2	L2	L2				113		L.02	L.1	13	8.5	
Intake - 3	2	2		23	14	167	L1.0	.04	.1	8	7.9	
Separator effluent - 1	60	80				120		L.02	3.7	80	7.3	5.04*
Separator effluent - 2	20	L15		200	57	66	7.3	.02	4.4	51		
Separator effluent - 3	30	31		100	50	121	6.2	.04	1.2	24	8.6	
Final effluent - 1	L6		L6	40	20	8	6.2	L.02	.2	37	7.4	1.2*
Final effluent - 2	L6		L6	36	18	10	5.0	L.02	.2	13	8.4	
Final effluent - 3	3		3	48	21	8	5.0	L.02	.1	3	7.8	
Refinery I												
Intake - 1	L3			4	5	L1	L1.0		.5	2	7.8	3.53
Intake - 2	L3			5	4	L1	L1.0			4	8.6	3.53
Intake - 3	L3					2			.4	5	7.6	3.53
Separator effluent - 1	88		77	260	89	38	3.4		.5	30	5.7	2.99
Separator effluent - 2	76	32		260	80	46	4.5			25	9.1	3.26
Separator effluent - 3	55	66		250	75	32	5.0		.6	42	8.9	3.29
Final effluent-1	L12			88	34	6	L1.0		.7	5	7.1	2.75
Final effluent-2	L12		L12	76	29	8	L1.0			3	7.2	2.27
Final effluent-3	L12		L12	72	29	10	1.7		.4	9	7.5	2.44

*Average flow during the sampling period.

TABLE III-5 (Continued)

Analytical Results for Traditional Parameters for the RSKERL and B&R Sampling Program

	Concentration (mg/l)											
	BOD-1	BOD-2	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH	Flow (MGD)
Refinery J												
Intake-1	L5			16	14	10	2.0	L.02	L.1	16	7.5	
Intake-2	2			40	19	3	L1.0	.02	L.1	11	7.8	
Intake-3			3	20	10	1	L1.0	L.02	.3	11	7.3	
Separator 1 effluent-1	51		39	210	60	54	2.0	.02	.7	74	8.9	
Separator 1 effluent-2	76		78	160	39	82	1.0	L.02	1.8	120	8.2	
Separator 1 effluent-3			50	160	55	22	1.7	.03	1.8	36	7.9	
Separator 2 effluent-1	85		G84	310	57	64	8.4	L.02	5.5	84	8.2	
Separator 2 effluent-2	G84		G84	690	200	196	14	.04	11	140	8.2	
Separator 2 effluent-3			G84	660	230	108	8.4	.02	15	250	8.2	
Separator 3 effluent-1	15		58	160	52	62	3.0	.02	1.8	25	7.4	.464
Separator 3 effluent-2	20		22	180	45	38	6.2	.02	5.3	23	7.3	.122
Separator 3 effluent-3			32	220	63	34	4.5	.04	1.5	54	7.3	.572
Separator 4 effluent-1	G80		100	310	66	36	3	L.02	6.8	65	7.7	
Separator 4 effluent-2	70		55	270	58	26	7.3	L.02	9.1	34	7.3	
Separator 4 effluent-3			60	430	97	94	8.4	.05	5.1	150	7.6	
Separator 5 effluent-1	10		10	83	23	26	2.0	.14	L.1	7	8.1	
Separator 5 effluent-2	12		10	75	22	16	1.0	.13	1.0	9	8.1	
Separator 5 effluent-3			18	92	31	48	L1.0	.09	12	25	7.1	
Bio-pond influent-1	96			610	50	24	22	.08	14	11	7.4	
Bio-pond influent-2	G84			570	100	16	24	.10	49	9	7.7	
Bio-pond influent-3			G84	480	120	18	20	.08	3.5	20	7.5	
Final effluent-1	6			87	34	20	6.8	L.02	.2	20	7.0	2.70
Final effluent-2	6			87	26	7	5.0	L.02	1.0	6	7.3	2.55
Final effluent-3			6	92	32	8	5.6	L.02	.9	16	7.9	2.73

TABLE III-5 (Continued)

Analytical Results for Traditional Parameters for the RSKERL and B&R Sampling Program

Sample-Day	BOD-1	BOD-2	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH	Flow (MGD)
	Concentration (mg/l)											
Refinery K												
Intake-1	4		4	27		12	L1.0	L.02	.4	9	8.1	14.1*
Intake-2	4		4	23	11	14	L1.0	L.02	.4	6		
Intake-3	L6		L6	24	10	10	1.0	L.02	.3	14	7.4	
DAF effluent-1	L120	L120	80	530	180	260	6.7	L.02	.8	590	7.8	5.4*
DAF effluent-2	220	210	200	1000	350	380	6.7	.04	1.6	190		
DAF effluent-3	L120	L120	L120	540	180	210	6.2	.02	.6	98	7.3	
Final effluent-1	8		7	96		21	2.2	L.02	.5	31	7.7	5.4*
Final effluent-2	L6		6	130	39	16	3.4	L.02	.3	15		
Final effluent-3	11		10	140	42	32	3.9	L.02	.3	12	7.3	
Refinery L												
Intake-1	2	3	2	56	13	290	L1.0	.25	.1		7.2	
Intake-2		L5	L3	20	10	220	L1.0	L.02	1.0		7.5	
Intake-3	L2	L3	L5	24	6	120	L1.0	.05	1.0		7.1	
Separator 1 effluent-1	100	130	120	390	110	140	6.2	L.02	.9		7.9	3.88
Separator 1 effluent-2		100	98	350	110	110	10	L.02	1.5		8.3	3.86
Separator 1 effluent-3	180	170	150	530	140	120	20	.07	1.2		8.6	4.28
Separator 2 effluent-1	32	38	34	200	49		7.8	.05	.8		8.0	7.15
Separator 2 effluent-2		31	42	210	56	36	15	L.02	1.7		6.3	5.37
Separator 2 effluent-3	40	42	40	170	46	48	9.0	L.02	.9		8.4	4.98
Final effluent-1	3		3	75	19	34	L1.0	L.02	.4		7.2	11.03
Final effluent-2			L4	44	15		3.4	.11	.3		6.9	9.23
Final effluent-3	11		8	71	14	21	3.0	.01	.9		7.2	9.26
Refinery M												
Intake-1	L6		L6	10	6	L1	L1.0	L.02	.2	4	8.0	
Intake-2	L6			9	10	L1	L1.0	L.02	.2	8	8.0	
Intake-3	L6		L6	8	4	L1	L1.0	L.02	.3	11	8.1	
DAF effluent-1	51	25	34	260	72	18	13	.75	.6	16	6.9	
DAF effluent-2	50	52	40	220	62	9	9.5	L.02	.5	18	8.4	
DAF effluent-3	36	40	34	220	66	7	12	L.02	.4	18	8.2	
Final effluent-1	L12		L12	92	18	8	L1.0	L.02	.4	13	7.7	1.64
Final effluent-2	L6		L6	86	16	15	L1.0	L.02	.4	12	7.9	1.52
Final effluent-3	L6		L6	73	14	11	1.0	L.02	.3	14	7.8	1.47

* Average flow during 72-hour sampling period.

TABLE III-5 (Continued)

Analytical Results for Traditional Parameters for the RSKERL and B&R Sampling Program

	Concentration (mg/l)											
	BOD-1	BOD-2	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH	Flow (MGD)
Refinery N												
Intake-1			L1	40	12	18	L1.0	L.02	.3		8.4	24.69
Intake-2		L5		16	8	22	L1.0	.07	.3		7.7	26.84
Intake-3		L2		28	12	26	L1.0	.09	1.1		7.3	25.91
Separator effluent-1			83	360	88	68	12	L.02	2.9		8.1	15.25
Separator effluent-2			100	430	120	112	15	L.02	8.1		8.1	15.25
Separator effluent-3			120	440	100	76	13	L.02	9.2		7.9	18.25
Chem. plant effluent-1			74	340	93	28	1.1	L.02	.7		6.8	0.8
Chem. plant effluent-2			140	810	240	36	L1.0	L.02	.9		6.6	0.95
Chem. plant effluent-3		34		240	69	40	2.0	L.02	.9		6.7	0.9
Final effluent-1			10	140	33	50	6.2	L.02	.6		8.6	14.75
Final effluent-2			8	120	33	40	6.7	L.02	.9		7.4	15.9
Final effluent-3			10	140	36	44	3.0	L.02	.9		7.4	17.6
Refinery O												
Intake-1	L2			11	10	10	L1.0	L.02	.5		7.1	
Intake-2	L5	L5		26	21	10	L1.0	.02	L.1		6.8	
Intake-3	L3	L2		12	25	14	L1.0	.02	.1		7.0	
DAF effluent-1	120			380	120	21	5.3	L.02	3.9		8.4	2.88*
DAF effluent-2	100	75		410	110	32	6.4	L.02	4.1		8.6	
DAF effluent-3	85	88		480	180	42	18	L.02	2.9		8.8	
Final effluent-1	6			150	48	24	2.5	L.02	.6		7.9	2.88*
Final effluent-2	L10		L10	140	40	26	3.1	.02	.5			
Final effluent-3	94		L8	120	52	24	2.5	L.02	.4		7.8	

*Average flow during 72-hour period.

TABLE III-5 (Continued)

Analytical Results for Traditional Parameters for the RSKERL and B&R Sampling Program

Sample-Day	Concentration (mg/1)											
	BOD-1	BOD-2	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH	Flow (MGD)
Refinery P												
Intake-1	L2			4	3	L1	L1.0	L.02	L.1		7.0	
Intake-2	L5	L5		6	7	L1	L1.0	L.02	L.1		6.8	
Intake-3	L2	L2		L4	7	L1	L1.0	L.02	L.1		6.3	
Separator effluent-1	320			600	170	68	11	L.02	25			
Separator effluent-2	210	220		540	140	78	16	.15	25		10.1	
Separator effluent-3	150	160		470	140	42	18	.05	23		9.9	
Final effluent-1	L5			64	16	11	1.4	L.02	.3			
Final effluent-2	L5		L5	49	24	2	2.0	L.02	.6		7.7	
Final effluent-3	L3		L3	41	31	7	2.0	L.02	L.1		7.5	
Refinery Q												
Intake-1	L2			4	8	3	L1.0	L.02	.4	5	7.1	
Intake-2	L2			4	11	2	L1.0	L.02	.3	9	7.4	
Intake-3	L3			24	9	L1	L1.0	L.02	.3	13	7.5	
Separator effluent-1	80		50	370	91	28	45	L.02	9.3	62	9.2	
Separator effluent-2	40		70	330	84	10	48	L.02	5.6		9.3	
Separator effluent-3	66		64	260	65	12	39	L.02	2.4	38	9.8	
Final effluent-1	28			260	59	38	53	L.02	.7	45	8.8	.2783
Final effluent-2	20			250	78	22	49	L.02	.6	45	8.3	.3086
Final effluent-3	30			230	60	26	42	L.02	.5	37	8.7	.3186

TABLE III-6

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS

FOR THE RSKERL AND B&R SAMPLING PROGRAM

VOLATILE ORGANICS (CONCENTRATIONS, ug/l)

Refinery A[a]

Compound		Intake Water	Separator Effluent	Final Effluent
4	Benzene	ND	G(100)	ND
23	Chloroform	70[b]	D(L 5)[b]	D (L 5)[b]
29	1,2-trans-Dichloroethylene	ND	20	ND
38	Ethylbenzene	ND	G(100)	ND
44	Methylene chloride	G (100)[b]	G(100)[b]	G(100)[b]
85	Tetrachloroethylene	ND	G(50)	D(L 10)
86	Toluene	ND	G(100)	ND

Refinery B[c]

		Intake Water	DAF Effluent	Final Effluent
4	Benzene	ND[b]	ND[b]	D(L 10)[b]
23	Chloroform	D(L 10)[d]	11[d]	D(L 10)[d]
44	Methylene chloride	22[d]	30[b]	ND[b]

Refinery C[e]

		Intake Water	Separator Effluent	Treated Effluent	Final Effluent
4	Benzene	ND	417[b]	ND	ND
10	1,2-Dichloroethane	ND	16	ND	ND
23	Chloroform	D(L 1)[b]	ND	ND	ND
38	Ethylbenzene	ND	38	ND	ND
44	Methylene chloride	85[b]	3[d]	7[d]	20[d]

Refinery D[a]

		Intake Water	Separator Effluent	Final Effluent
4	Benzene	ND	G(100)	ND
38	Ethylbenzene	ND	G(100)	ND
86	Toluene	ND	G(100)	ND

Refinery E[a]

		Intake Water	DAF Effluent	Final Effluent
4	Benzene	ND	G(100)	ND
38	Ethylbenzene	ND	G(100)	ND
44	Methylene chloride	50[d]	10[d]	10[d]
85	Tetrachloroethylene	50	ND	ND
86	Toluene	ND	G(100)	ND
87	Trichloroethylene	20	ND	ND

Refinery F[a]

		Intake Water	Cooling Tower Blowdown	Final Effluent
6	Carbon tetrachloride	G(50)	ND	ND
11	1,1,1-Trichloroethane	G(50)	ND	ND
44	Methylene chloride	D(L 10)[d]	70[b]	D(L 10)[d]

Refinery G[e]

		Intake Water	Separator Effluent	DAF Effluent	Final Effluent
4	Benzene	D(L 1)	409	2,005	D(L 1)
44	Methylene chloride	22[d]	293[b]	563[b]	12[d]
86	Toluene	D(L 1)	96	76,405	D(L 1)

Refinery H[c]

		Intake Water	Separator Effluent	Final Effluent
4	Benzene	ND[b]	ND[b]	12[b]
23	Chloroform	D(L 10)[d]	55[b]	66[b]
44	Methylene chloride	ND	ND	70[b]
86	Toluene	ND	ND	D(L 10)

TABLE III-6 (Continued)

Refinery I[e]

		Intake Water[f]	Separator Effluent	Final Effluent
4	Benzene	D(L 1)/D(L 1)[b]	2434[b]	2[b]
23	Chloroform	8/d(L 1)[b]	ND	ND
38	Ethylbenzene	ND/ND	812	ND
44	Methylene chloride	12/7[d]	19[d]	74[b]
86	Toluene	ND/ND	11767[b]	D(L 1)[b]

Refinery K[c]

		Intake Water	Separator Effluent	Final Effluent
4	Benzene	ND[b]	20[b]	ND[b]
10	1,2-Cichloroethane	ND	ND[b]	D(L 10)
15	1,1,2,2-Tetrachloroethane	ND	ND[b]	D(L 10)
23	Chloroform	D(L 10)[d]	100[b]	D(L 10)[d]
30	1,2-trans-Dichloroethylene	ND	ND[b]	D(L 10)
38	Ethylbenzene	ND	ND[b]	D(L 10)
44	Methylene chloride	ND[b]	1100	ND[b]
85	Tetrachloroethylene	ND	ND[b]	D(L 10)
86	Toluene	ND	D(L 10)[b]	ND

Refinery L[a]

		Intake Water	Separator 1 Effluent	Separator 2 Effluent	Final Effluent
4	Benzene	ND	G(100)	G(100)	ND
23	Chloroform	ND	10	10	ND
38	Ethylbenzene	ND	G(100)	G(100)	ND
44	Methylene chloride	40[b]	G(100)[b]	50[b]	60[b]
86	Toluene	ND	G(100)	G(100)	ND

Refinery M[c]

		Intake Water	DAF Effluent	Final Effluent
4	Benzene	14[b]	12[d]	11[d]
6	Carbon tetrachloride	ND	D(L 10)	D(L 10)
23	Chloroform	44[b]	55[d]	D(L 10)[d]
44	Methylene chloride	91	180[d]	D(L 10)[d]
86	Toluene	D(L 10)	D(L 10)	D(L 10)

Refinery N[a]

		Intake Water	Chem.Plant Effluent	Separator Effluent	Final Effluent
4	Benzene	ND	90	G(100)	6[d]
23	Chloroform	ND	10	15	ND
38	Ethylbenzene	ND	20	G(100)	ND
44	Methylene chloride	G(100)[b]	G(100)[b]	G(100)[b]	G(100)[b]
86	Toluene	ND	G(100)	G(100)[b]	35

Refinery O[c]

		Intake Water	DAF Effluent	Final Effluent
4	Benzene	ND	D(L 10)[b]	D(L 10)[d]
6	Carbon tetrachloride	D(L 10)	ND	D(L 10)[b]
23	Chloroform	55	13	32[d]
44	Methylene chloride	130	ND	44[d]
86	Toluene	D(L 10)	16	ND[b]

Refinery P[c]

		Intake Water	Separator Effluent	Final Effluent
4	Benzene	D(L 10)[b]	1,100[b]	D(L 10)[b]
6	Carbon tetrachloride	ND	ND	D(L 10)[b]
15	1,1,2,2-Tetrachloroethane	D(L 10)	ND	D(L 10)
23	Chloroform	D(L 10)[d]	100[b]	D(L 10)[b]
30	1,2-trans-Dichloroethylene	11	ND	ND
38	Ethylbenzene	ND	28	ND
44	Methylene chloride	ND	1,600[b]	41
85	Tetrachloroethylene	D(L 10)	ND	ND
86	Toluene	D(L 10)	655	ND
87	Trichloroethylene	D(L 10)	ND	D(L 10)

TABLE III-6 (Continued)

		Refinery Q[e]		
		Intake Water	Separator Effluent	Final Effluent
4	Benzene	D(L 1)	894	ND
23	Chloroform	ND	6[b]	ND
44	Methylene chloride	6[d]	4[d]	3[d]
48	Dichlorobromomethane	ND	24	ND
86	Toluene	ND	167	ND

Notes:

Volatile organic compounds not listed for a refinery were not detected in samples taken at that refinery.

ND - Compound was not detected.

D(Lx) - Compound was detected at some concentration less than x, but the concentration could not be quantified.

G(x) - Compound was detected at a level greater than x.

a) Midwest Research Institute conducted the analyses for volatile organic compounds in samples from Refinèries A, D, E, F, L, N. See Reference No. 149.

b) Compound was detected in sample blank.

c) NUS Corporation conducted the analyses for volatile organic compounds in samples from Refineries B, H, K, M, O, P.

d) Compound was detected at a greater level in sample blank than in sample.

e) Gulf South Research Institute conducted the analyses for volatile organic compounds in samples from Refineries C, G, I, Q. These data represent results from one-time grab samples collected during revisits to these refineries. Additional sampling was necessary because the initial volatile organic results had been considered invalid due to improper analytical techniques. Since the revisit to Refinery J was conducted by an EPA regional surveillance and analysis sampling team, the results are not presented in this table.

f) Concentrations presented are for unpreserved/preserved samples.

TABLE III-7

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS

FOR THE RSKERL AND B&R SAMPLING PROGRAM

SEMIVOLATILE ORGANICS (CONCENTRATIONS, ug/1)

Compound	Refinery A[a]		
	Intake Water	Separator Effluent[b]	Final Effluent
Base - Neutral Extractables			
1 Acenaphthene	ND	37	ND
55 Naphthalene	ND	68	ND
77 Acenaphthylene	ND	4	ND
81 Phenanthrene/78 Anthracene[c]	D(L0.1)	5	ND
68 Di-n-butyl phthalate	0.2	1.3	0.7
70 Diethyl phthalate	ND	12	ND
Acid Extractables			
65 Phenol	ND	13	ND

	Refinery B[d]		
	Intake Water	DAF Effluent	Final Effluent
Base-Neutral Extractables	ND	ND	ND
Acid Extractables			
22 Parachlorometa cresol	ND	ND	D (L 10)
34 2,4 - Dimethylphenol	ND	10,000	D (L 10)
58 4- Nitrophenol	ND	ND	D (L 10)
65 Phenol	ND	ND	D (L 10)

	Refinery C-1[e]			
	Intake Water	Separator Effluent	Treated Effluent	Final Effluent
Base-Neutral Extractables				
55 Naphthalene	ND	950	ND	ND
81 Phenanthrene/78 Anthracene	ND	190	ND	ND
66 Bis(2-ethylhexyl) phthalate	150	290	900	310
Acid Extractables				
65 Phenol	ND	2200	ND	ND

	Refinery C-2[f]
	Final Effluent
Base-Neutral Extractables	ND
Acid Extractables	ND

	Refinery D[a]		
	Intake Water	Separator Effluent[g]	Final Effluent
Base-Neutral Extractables			
39 Fluoranthene	ND	3	ND
55 Naphthalene	2	190	ND
73 Benzo (a) pyrene	ND	ND	3
76 Chrysene	ND	0.1	1.4
81 Phenanthrene/78 Anthracene[c]	D(L0.1)	140	ND
84 Pyrene	ND	11	7
Acid Extractables	ND	ND	ND

TABLE III-7(continued)

Refinery E[a]

	Intake Water	DAF Effluent[b]	Final Effluent	Final Effluent[h]
Base-Neutral Extractables				
1 Acenaphthene	1.8	150	ND	ND
25 1,2-Dichlorobenzene	D(L0.5)	ND	ND	ND
27 1,4-Dichlorobenzene	D(L0.5)	ND	ND	ND
39 Fluoranthene	D(L0.2)	ND	ND	ND
55 Naphthalene	ND	106	ND	ND
76 Chrysene	ND	0.3	D(L0.1)	ND
80 Fluorene	ND	110	ND	ND
81 Phenanthrene/78 Anthracene[c]	ND	50	ND	D(L0.1)
84 Pyrene	D(L0.1)	5	D(L0.5)	D(L0.5)
68 Di-n-butyl phthalate	0.4	ND	ND	ND
Acid Extractables				
34 2,4-Dimethylphenol	ND	G(100)	ND	ND
65 Phenol	ND	G(100)	ND	ND

Refinery F[a]

	Intake Water[i]	Cooling Tower Blowdown[b]	Final Effluent
Base-Neutral Extractables			
39 Fluoranthene	29	ND	ND
73 Benzo (a) pyrene	33	10	1.3
76 Chrysene	49	7	0.8
81 Phenanthrene/78 Anthracene[c]	160	2	ND
84 Pyrene	140	10	ND
Acid Extractables	ND	ND	ND

Refinery G-1[e]

	Intake Water	Separator Effluent	DAF Effluent	Final Effluent
Base-Neutral Extractables				
39 Fluoranthene/84 Pyrene	ND	40	ND	ND
55 Naphthalene	ND	1100	700	ND
76 Chrysene/72 Benzo (a) Anthracene	ND	40	ND	ND
81 Phenanthrene/78 Anthracene	ND	1100	600	ND
66 Bis (2-ethylhexyl)phthalate	1100	700	1100	850
Acid Extractables				
65 Phenol	10	4900	2400	ND

Refinery G-2[f]

	Final Effluent
Base-Neutral Extractables	
70 Diethyl phthalate	1
Acid Extractables	ND

Refinery H[d]

	Intake Water	Separator Effluent	Final Effluent
Base-Neutral Extractables			
66 Bis(2-ethylhexyl)phthalate	ND	ND	D (L 10)
Acid Extractables			
31 2,4-Dichlorophenol	ND	ND	10
34 2,4-Dimethylphenol	ND	175	ND
65 Phenol	ND	440	ND

TABLE III-7(continued)

Refinery I-1[e]

	Intake Water	Separator Effluent	Final Effluent
Base-Neutral Extractables			
55 Naphthalene	ND	290	ND
66 Bis(2-ethylhexyl)phthalate	950	300	600
68 Di-n-butyl phthalate	30	ND	10
Acid Extractables			
65 Phenol	ND	390	ND

Refinery I-2[f]

	Final Effluent
Base-Neutral Extractable	ND
Acid Extractable	ND

Refinery J[e]

	Intake Water	Separator 1 Effluent	Separator 2 Effluent	Separator 3 Effluent
Base-Neutral Extractables				
1 Acenaphthene	ND	ND	ND	ND
39 Fluoranthene/84 Pyrene	ND	30	ND	ND
55 Naphthalene	ND	ND	350	ND
76 Chrysene/72 Benzo (a) anthracene	ND	30	30	50
81 Phenanthrene/78 Anthracene	ND	30	90	ND
80 Fluorene	ND	ND	ND	ND
66 Bis(2-ethylhexyl)phthalate	110	180	300	50
70 Diethyl phthalate	ND	ND	ND	ND
71 Dimethyl phthalate	ND	ND	ND	ND
Acid Extractables				
34 2,4-Dimethylphenol	ND	ND	ND	ND
64 Pentachlorophenol	ND	ND	ND	ND
65 Phenol	ND	420	160	ND

Refinery J[e] (continued)

	Separator 4 Effluent	Separator 5 Effluent	Bio-Pond Influent	Final Effluent
Base-Neutral Extractables				
1 Acenaphthene	50	ND	ND	ND
39 Fluoranthene/84 Pyrene	20	ND	ND	ND
55 Naphthalene	ND	ND	ND	ND
76 Chrysene/72 Benzo(a)anthracene	40	ND	ND	ND
81 Phenanthrene/78 Anthracene	230	ND	ND	ND
80 Fluorene	80	ND	ND	ND
66 Bis(2-ethylhexyl)phthalate	600	ND	210	190
70 Diethyl phthalate	ND	ND	ND	30
71 Dimethyl phthalate	ND	ND	ND	3
Acid Extractables				
34 2,4-Dimethylphenol	650	ND	750	ND
64 Pentachlorophenol	850	ND	ND	ND
65 Phenol	16,000	ND	G(12,000)	ND

Refinery K[d]

	Intake Water	Separator Effluent	Final Effluent
Base-Neutral Extractables	ND	ND	ND
Acid Extractables			
24 2-Chlorophenol	ND	315	ND
34 2,4-Dimethylphenol	ND	1,150	ND
58 4-Nitrophenol	ND	5,800	ND
59 2,4-Dinitrophenol	ND	11,000	ND
65 Phenol	ND	105	ND

TABLE III-7 (continued)

Refinery L[a]

		Intake Water	Separator 1[g] Effluent	Separator 2[g] Effluent	Final Effluent
Base-Neutral Extractables					
1	Acenaphthene	29	ND	3,000	6
39	Fluoranthene	0.2	ND	9	D(L0.1)
55	Naphthalene	1	500	280	0.1
76	Chrysene	ND	20	2	0.3
77	Acenaphthylene	0.2	ND	ND	ND
80	Fluorene	1	270	300	ND
81	Phenanthrene/78 Anthracene[c]	1	230	ND	1
84	Pyrene	0.3	ND	7	D(L0.1)
Acid Extractables					
34	2,4-Dimethylphenol	ND	G(100)	G(100)	ND
65	Phenol	ND	G(100)	G(100)	ND

Refinery M[d]

		Intake Water	DAF Effluent	Final Effluent
Base-Neutral Extractables		ND	ND	ND
Acid Extractables				
22	Parachlorometa cresol	ND	ND	10
34	2,4-Dimethylphenol	ND	18,300	ND
58	4-Nitrophenol	ND	1,400	ND
59	2,4-Dinitrophenol	ND	2,660	ND
65	Phenol	D(L 10)	33,500	D(L 10)

Refinery N[a]

		Intake Water	Chem. Plant Effluent	Separator[g] Effluent	Final Effluent
Base-Neutral Extractables					
1	Acenaphthene	ND	ND	522	ND
39	Fluoranthene	ND	ND	8	ND
55	Naphthalene	ND	27	302	ND
76	Chrysene	ND	D(L0.1)	6	ND
77	Acenaphthylene	ND	ND	87	ND
81	Phenanthrene/78 Anthracene[c]	ND	1	140	ND
84	Pyrene	ND	1	16	ND
Acid Extractables					
22	Parachlorometa cresol	ND	10	ND	ND
34	2,4-Dimethylphenol	ND	G(100)	71	ND
65	Phenol	ND	40	G(100)	ND

Refinery O[d]

		Intake Water	DAF Effluent	Final Effluent
Base-Neutral Extractables				
1	Acenaphthene	ND	390	ND
39	Fluoranthene	ND	ND	ND
54	Isophorone	ND	2,500	ND
55	Naphthalene	ND	3,750	ND
68	Di-n-butyl phthalate	ND	ND	ND
71	Dimethyl phthalate	ND	ND	ND
76	Chrysene	ND	ND	ND
77	Acenaphthylene	ND	530	ND
78	Anthracene	ND	1,750	ND
80	Fluorene	ND	495	ND
81	Phenanthrene	ND	1,750	ND
84	Pyrene	ND	ND	ND
Acid Extractables				
34	2,4-Dimethylphenol	ND	2,000	ND
65	Phenol	ND	1,900	ND

TABLE III-7(continued)

	Refinery P[d]		
	Intake Water	Separator Effluent	Final Effluent
Base-Neutral Extractables			
1 Acenaphthene	ND	315	ND
54 Isophorone	ND	3,550	ND
55 Naphthalene	ND	3,200	ND
77 Acenaphthylene	ND	665	ND
78 Anthracene	ND	660	ND
81 Phenanthrene	ND	660	ND
Acid Extractables			
57 2-Nitrophenol	D (L 10)	1,350	ND
58 4-Nitrophenol	D (L 10)	20	ND
59 2,4-Dinitrophenol	ND	110	ND
60 4,6-Dinitro-o-cresol	ND	60	ND

	Refinery Q-1[e]		
	Intake Water	Separtor Effluent	Final Effluent
Base-Neutral Extractables			
66 Bis(2-ethylhexyl)phthalate	1,100	320	2,000
68 Di-n-butyl phthalate	20	ND	ND
71 Dimethyl phthalate	20	ND	ND
Acid Extractables			
65 Phenol	10	60	ND

	Refinery Q-2[f]
	Final Effluent
Base-Neutral Extractables	
70 Diethyl phthalate	1
Acid Extractables	ND

NOTES:

Semivolatile organic compounds not listed for a refinery were not detected in samples taken at that refinery.

ND - Compound was not detected.

D(LX) - Compound was detected at some concentration less than X, but the concentration could not be quantified.

G(X) - Compound was detected at a level greater than X.

(a) Midwest Research Institute conducted the analyses for semivolatile organic compounds in samples from Refineries A,D,E,F,L,N. See Reference No. 149.

(b) Base-neutral extract was diluted 1:10 before analysis.

(c) Concentrations represent sums for these two compounds which elute simultaneously and have the same major ions for GC/MS.

(d) NUS Corporation conducted the analyses for semivolatile organic compounds in samples from Refineries B, H, K, M, O, P.

(e) Ryckman, Edgerley, Tomlinson & Associates and Gulf South Research Institute conducted the analyses for semivolatile organic compounds in samples from Refineries C,G,I,J,Q.

(f) Gulf South Research Institute conducted the analyses for semivolatile organic compounds in additional samples from Refineries C,G,I,Q. These data represent results from one-time grab samples collected during revisits to these refineries. Since the revisit to Refinery J was conducted by an EPA regional surveillance and analysis sampling team, the results are not presented in this table.

(g) Both acidic and base-neutral extracts were diluted 1:10 before analysis.

(h) This sample was stored for 6 weeks prior to extraction for base-neutral and acidic organic compounds.

(i) Base-neutral extract was diluted 1:5 before analysis.

TABLE III-8

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS

FOR THE RSKERL AND B&R SAMPLING PROGRAM

PESTICIDES (CONCENTRATIONS, ug/l)

Refinery A[a]

Compound	Intake Water	Separator Effluent	Final Effluent
109 PCB-1239	ND	0.9	ND

Refinery B[b]

	Intake Water	DAF Effluent	Final Effluent
94 4,4'-DDD	ND	D(L 5)	ND
97 Endosulfan sulfate	ND	D(L 5)	ND
100 Heptachlor	ND	D(L 5)	D(L 5)
103 b-BHC-Beta	ND	D(L 5)	D(L 5)
104 r-BHC-Gamma	ND	D(L 5)	ND
106 PCB-1242	ND	D(L 10)	D(L 10)
107 PCB-1254	ND	D(L 10)	D(L 10)
108 PCB-1221	ND	D(L 10)	D(L 10)
109 PCB-1232	ND	D(L 10)	D(L 10)
110 PCB-1248	ND	D(L 10)	D(L 10)
111 PCB-1260	ND	D(L 10)	D(L 10)
112 PCB-1016	ND	D(L 10)	D(L 10)

Refinery C[a]

	Intake Water	Separator Effluent	Treated Effluent	Final Effluent
Pesticides	ND	ND	ND	ND

Refinery D[a]

	Intake Water	Separator Effluent	Final Effluent
106 PCB-1242	ND	1.1	ND
108 PCB-1221	ND	ND	D(L 5)

Refinery E[a]

	Intake Water	DAF Effluent	Final Effluent
106 PCB-1242	ND	0.2	ND

Refinery F[a]

	Intake Water	Cooling Tower Blowdown	Final Effluent
91 Chlordane	2.8	ND	ND
103 b-BHC-Beta	ND	0.7	ND
108 PCB-1221	ND	0.1	ND

Refinery G[a]

	Intake Water	Separator Effluent	DAF Effluent	Final Effluent
95 a-Endosulfan-Alpha	ND	ND	0.1	ND
106 PCB-1242	ND	0.5	0.5	ND
109 PCB-1232	ND	ND	3.5	ND
112 PCB-1016	ND	1.8	7.9	ND

Refinery H[b]

	Intake Water	Separator Effluent	Final Effluent
89 Aldrin	ND	D(L 5)	ND
93 4,4 -DDE	ND	7	ND
105 g-BHC-Delta	ND	D(L 5)	ND
106 PCB-1242	ND	D(L 10)	D(L 10)
107 PCB-1254	ND	D(L 10)	D(L 10)
108 PCB-1221	ND	D(L 10)	D(L 10)
109 PCB-1232	ND	D(L 10)	D(L 10)
110 PCB-1248	ND	D(L 10)	D(L 10)
111 PCB-1260	ND	D(L 10)	D(L 10)
112 PCB-1016	ND	D(L 10)	D(L 10)

TABLE III-8(Continued)

Refinery I[a]

	Intake Water	Separator Effluent	Final Effluent
Pesticides	ND	ND	ND

Refinery J[a]

	Intake Water	Separator 1 Effluent	Separator 2 Effluent	Separator 3 Effluent
106 PCB-1242	ND	ND	0.5	ND
109 PCB-1232	ND	ND	0.5	ND
112 PCB-1016	ND	ND	0.2	ND

Refinery J[a] (continued)

	Separator 4 Effluent	Separator 5 Effluent	Bio-Pond Influent	Final Effluent
106 PCB-1242	ND	ND	0.1	ND
109 PCB-1232	ND	ND	ND	ND
112 PCB-1016	ND	ND	ND	ND

Refinery K[b]

	Intake Water	Separator Effluent	Final Effluent
101 Heptachlor epoxide	ND	D(L 5)	ND
106 PCB-1242	ND	D(L 10)	D(L 10)
107 PCB-1254	ND	D(L 10)	D(L 10)
108 PCB-1221	ND	D(L 10)	D(L 10)
109 PCB-1232	ND	D(L 10)	D(L 10)
110 PCB-1248	ND	D(L 10)	D(L 10)
111 PCB-1260	ND	D(L 10)	D(L 10)
112 PCB-1016	ND	D(L 10)	D(L 10)

Refinery L[a]

	Intake Water	Separator 1 Effluent	Separator 2 Effluent	Final Effluent
106 PCB-1242	0.2	5.2	ND	ND

Refinery M[b]

	Intake Water	DAF Effluent	Final Effluent
106 PCB-1242	ND	D(L 10)	D(L 10)
107 PCB-1254	ND	D(L 10)	D(L 10)
108 PCB-1221	ND	D(L 10)	D(L 10)
109 PCB-1232	ND	D(L 10)	D(L 10)
110 PCB-1248	ND	D(L 10)	D(L 10)
111 PCB-1260	ND	D(L 10)	D(L 10)
112 PCB-1016	ND	D(L 10)	D(L 10)

Refinery N[a]

	Intake Water	Chemical Plant Effluent	Separator Effluent	Final Effluent
101 Heptachlor epoxide	ND	4.6	ND	ND
108 PCB-1221	ND	ND	0.1	ND
109 PCB-1232	ND	0.1	0.5	ND
112 PCB-1016	ND	1.3	1.9	ND

Refinery O[b]

	Intake Water	DAF Effluent	Final Effluent
102 a-BHC-Alpha	ND	D(L 10)	ND

Refinery P[b]

	Intake Water	Separator Effluent	Final Effluent
89 Aldrin	ND	12	ND
96 b-Endosulfan-Beta	ND	13	ND
100 Heptachlor	ND	D(L 5)	ND
103 b-BHC-Beta	ND	D(L 5)	ND
105 g-BHC-Delta	ND	12	ND

TABLE III-8(Continued)

	Refinery Q[a]		
	Intake Water	Separator Effluent	Final Effluent
Pesticides	ND	ND	ND

Notes: Pesticide compounds not listed for a refinery were not detected in samples taken at that refinery.

ND-Compound was not detected.

D(Lx)-Compound was detected at some concentration less than x, but the concentration could not be quantified.

a) Ryckman, Edgerley, Tomlinson and Associates conducted the analyses for pesticide compounds in samples from Refineries A,C,D,E,F,G,I,J,L,N,Q. Since these results have not been verified by GC/MS, the reported identifications must be considered tentative.

b)NUS Corporation conducted the analyses for pesticide compounds in samples from Refineries B,H,K,M,O,P.

TABLE III-9

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS FOR THE RSKERL AND B&R SAMPLING PROGRAM CYANIDE, PHENOLICS, MERCURY (CONCENTRATIONS, mg/1)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery A				
Intake-1	2	L.01[b]	L.010	
Intake-1	1			.0001
Intake-2	2	L.01	L.010	
Intake-2	1			.0001
Intake-3	2	L.01	L.011	
Intake-3	1			.0001
Intake-composite	2			L.0005
Intake-composite	1			.0001
Separator effluent-1	2	.05	L.52	
Separator effluent-1	1			.0002
Separator effluent-2	2	.06	.14	
Separator effluent-2	1			.0002
Separator effluent-3	2	.04	.15	
Separator effluent-3	1			
Separator effluent-composite	2			L.0005
Separator effluent-composite	1			.0008
Final effluent-1	2	L.03	L.021	
Final effluent-1	1			.0002
Final effluent-2	2	L.03	.010	
Final effluent-2	1			.0002
Final effluent-3	2	L.03	L.011	
Final effluent-3	1			.0002
Final effluent-composite	2			L.0005
Final effluent-composite	1			.0003
Refinery B				
Intake-1	2	L.02	L.010	
Intake-2	2	L.02	L.005	
Intake-3	2	L.02	L.005	
Intake-composite	2			L.0005
DAF effluent-1	2	.04	32.	
DAF effluent-2	2	.05	34.	
DAF effluent-3	2	.04	22.	
DAF effluent-composite	2			L.0005
Final effluent-1	2	L.02	.064	
Final effluent-2	2	L.02	.048	
Final effluent-3	2	L.02	.045	
Final effluent-composite	2			L.0005

TABLE III-9(Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery C[c]				
Intake-1	1			.0014
Intake-1	3	L.01	.004	.0010
Intake-2	1			.0016
Intake-2	3	L.01	.006	.0060
Intake-3	1			.0013
Intake-3	3	L.01	.004	.0010
Intake-composite	1			.0013
Separator effluent-1	1			.0011
Separator effluent-1	3	1.1	12.	L.0010
Separator effluent-2	1			.0012
Separator effluent-2	3	.12	3.2	.0060
Separator effluent-3	1			.0015
Separator effluent-3	3	.07	1.6	.0020
Separator effluent-3	3	.07	1.4	.0050
Separator effluent-3	3			.0780
Separator effluent-composite	1			.0012
Treated effluent-1	1			.0008
Treated effluent-1	3	.12	L.001	.0020
Treated effluent-1	3			.0006
Treated effluent-2	1			.0010
Treated effluent-2	3	.17	.011	.0050
Treated effluent-2	3		.016	
Treated effluent-3	1			.0010
Treated effluent-3	3	.08	L.001	.0090
Treated effluent-3	3			.0060
Treated effluent-composite	1			.0012
Final effluent-1	1			.0011
Final effluent-1	3	.03	.002	.0010
Final effluent-2	1			.0014
Final effluent-2	3	.05	.006	.0010
Final effluent-2	3	.04		
Final effluent-3	1			.0013
Final effluent-3	3	.06	.002	.0060
Final effluent-composite	1			.0013
Intake-4	3	L.02		L.0001
Separator effluent-4	3	L.02		L.0004
Treated effluent-4	3	.05		L.0002
Final effluent-4	3	.07		.0005
Refinery D				
Intake-1	2	L.02		
Intake-1	1			.0001
Intake-2	2	L.02		
Intake-2	1			.0002

TABLE III-9(Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery D (Cont.)				
Intake-3	2	L.02	0.23	
Intake-3	1			.0001
Intake-composite	2			L.0005
Intake-composite	1			.0002
DAF effluent-1	2	.05	3.7	
DAF effluent-1	1			.0002
DAF effluent-2	2	.06	5.1	
DAF effluent-2	1			.0001
DAF effluent-3	2	.04	8.0	
DAF effluent-3	1			.0002
DAF effluent-composite	2			L.0005
DAF effluent-composite	1			L.0001
Final effluent-1	2	.03		
Final effluent-1	1			.0002
Final effluent-2	2	.03		
Final effluent-2	1			.0002
Final effluent-3	2	L.02		
Final effluent-3	1			.0002
Final effluent-composite	2			L.0005
Final effluent-composite	1			.0002
Refinery E				
Intake-1	2	.03	L.011	
Intake-1	1			L.0001
Intake-2	2	L.03	.015	
Intake-2	1			L.0001
Intake-3	2	L.03	L.010	
Intake-3	1			L.0001
Intake-composite	2			L.0005
Intake-composite	1			L.0001
DAF effluent-1	2	L.03	6.8	
DAF effluent-1	1			L.0001
DAF effluent-2	2	L.03	9.9	
DAF effluent-2	1			L.0001
DAF effluent-3	2	L.03	11.0	
DAF effluent-3	1			L.0001
DAF effluent-composite	2			L.0005
DAF effluent-composite	1			L.0001
Final effluent-1	2	L.03	.013	
Final effluent-1	1			.0001
Final effluent-2	2	L.03	.011	
Final effluent-2	1			L.0001
Final effluent-3	2	L.03	L.010	
Final effluent-3	1			.0001
Final effluent-composite	2			L.0005
Final effluent-composite	1			.0001

TABLE III-9 (Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery F				
Intake-1	2	L.03	.21	
Intake-1	1			.0002
Intake-2	2	L.03	.21	
Intake-2	1			.0007
Intake-3	2	L.03	.21	
Intake-3	1			.0009
Intake-composite	2			L.0005
Intake-composite	1			.0006
Cooling tower blowdown-1	2	.52	.037	
Cooling tower blowdown-1	1			.0004
Cooling tower blowdown-2	2	.83	.041	
Cooling tower blowdown-2	1			.0005
Cooling tower blowdown-3	2	.83	.057	
Cooling tower blowdown-3	1			.0007
Cooling tower blowdown-composite	2			L.0005
Cooling tower blowdown-composite	1			.0005
Final effluent-1	2	.06	.022	
Final effluent-1	1			.0003
Final effluent-2	2	.07	.024	
Final effluent-2	1			.0003
Final effluent-3	2	.08	.026	
Final effluent-3	1			.0003
Final effluent-composite	2			L.0005
Final effluent-composite	1			.0004
Refinery G[c]				
Intake-1	1			.0013
Intake-1	3	L.01	.010	.0005
Intake-2	1			.0021
Intake-2	3	L.01	L.001	.0004
Intake-3	1			.0023
Intake-3	3	L.01	.008	L.0005
Intake-composite	1			.0008
Separator effluent-1	1			.0017
Separator effluent-1	3	1.2	23.	L.0002
Separator effluent-1	3	1.2	24.	
Separator effluent-2	1			.0009
Separator effluent-2	3	1.2	25.	L.0002
Separator effluent-3	1			.0018
Separator effluent-3	3	1.5	23.	.0002
Separator effluent-composite	1			.0003
DAF effluent-1	1			.0011
DAF effluent-1	3	1.9	22.	L.0002
DAF effluent-2	1			.0011
DAF effluent-2	3	2.0	26.	.0005

TABLE XII-9(Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery G (Cont.)				
DAF effluent-3	1			.0010
DAF effluent-3	3	3.0	22.	.0010
DAF effluent-composite	1			.0003
Final effluent-1	1			.0008
Final effluent-1	3	.09	.047	.0010
Final effluent-1	3			.0007
Final effluent-2	1			.0018
Final effluent-2	3	.07	.020	L.0002
Final effluent-2	3	.09		
Final effluent-3	1			.0008
Final effluent-3	3	.30	.032	.0005
Final effluent-composite	1			.0004
Intake-4	3	L.02		
Separator effluent-4	3	.60		
DAF effluent-4	3	.13		
Final effluent-4	3	.17		
Refinery H				
Intake-1	2	L.02	.011	
Intake-2	2	L.02	L.005	
Intake-3	2	L.02	L.005	
Intake-composite	2			L.0005
Separator effluent-1	2	.16	2.3	
Separator effluent-2	2	.07	2.2	
Separator effluent-3	2	.08	1.9	
Separator effluent-composite	2			L.0005
Final effluent-1	2	.02	L.010	
Final effluent-2	2	.01	.010	
Final effluent-3	2	.02	.012	
Final effluent-composite	2			L.0005
Refinery I				
Intake-1	1			.0013
Intake-1	3	L.005	L.001	.0007
Intake-2	1			.0011
Intake-2	3	L.005	L.001	.0005
Intake-3	1			.0014
Intake-3	3	L.005	.004	.0007
Separator effluent-1	1			.0012
Separator effluent-1	3	.010	6.0	L.0002
Separator effluent-1	3		5.6	L.0002
Separator effluent-2	1			.0028
Separator effluent-2	3	.015	4.4	.0008
Separator effluent-3	1			.0011
Separator effluent-3	3	L.005	5.0	.0008

TABLE III-9(Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery I (Cont.)				
Separator effluent-3	3		5.2	
Final effluent-1	1			.0042
Final effluent-1	3	L.005	.018	L.0002
Final effluent-1	3	L.005		
Final effluent-2	1			.0012
Final effluent-2	3	L.005	.014	L.0002
Final effluent-2	3	L.005		
Final effluent-3	3	L.005	.012	.0010
Refinery J				
Intake-1	1			.0007
Intake-1	3	.01	.017	.0001
Intake-1	3			.0004
Intake-2	1			.0009
Intake-2	3	.01	.024	.0002
Intake-3	1			.0019
Intake-3	3	L.01	.002	.0020
Intake-3	3			.0070
Intake-3	3			.0070
Intake-composite	1			.0005
Separator-1 effluent-1	1			.0001
Separator-1 effluent-1	3	.01	1.0	.0030
Separator-1 effluent-2	1			.0012
Separator-1 effluent-2	3	.01	1.0	L.0001
Separator-1 effluent-2	3	.01		
Separator-1 effluent-3	1			.0012
Separator-1 effluent-3	3	.01	.2	.0010
Separator-1 effluent-composite	1			.0005
Separator-2 effluent-1	1			.0028
Separator-2 effluent-1	3	.01	1.0	.0001
Separator-2 effluent-1	3		1.0	
Separator-2 effluent-2	1			.0016
Separator-2 effluent-2	3	.01	2.0	.0050
Separator-2 effluent-3	1			.0003
Separator-2 effluent-3	3	.01	2.5	L.0010
Separator-2 effluent-composite	1			.0006
Separator-3 effluent-1	1			.0002
Separator-3 effluent-1	3	.01	.690	L.0001
Separator-3 effluent-1	3		.5	
Separator-3 effluent-2	1			.0006
Separator-3 effluent-2	3	.01	1.3	.0010
Separator-3 effluent-3	1			.0009
Separator-3 effluent-3	3	.01	.270	.0006
Separator-3 effluent-composite	1			.0010

TABLE III-9 (Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery J (Cont.)				
Separator-4 effluent-1	1			.0002
Separator-4 effluent-1	3	.06	9.5	.0002
Separator-4 effluent-2	1			.0013
Separator-4 effluent-2	3	.05	2.0	.0050
Separator-4 effluent-2	3		2.0	.0070
Separator-4 effluent-3	1			.0016
Separator-4 effluent-3	3	.06	1.5	.0020
Separator-4 effluent-3	3		1.5	
Separator-4 effluent-composite	1			.0004
Separator-5 effluent-1	1			.0003
Separator-5 effluent-1	3	.02	.294	L.0001
Separator-5 effluent-2	1			.0011
Separator-5 effluent-2	3	.02	.214	.0002
Separator-5 effluent-3	1			.0016
Separator-5 effluent-3	3	.02	.246	.0020
Separator-5 effluent-composite	1			.0005
Bio-pond influent-1	3	.22	120.	.0020
Bio-pond influend-2	3	.34	110.	.0060
Bio-pond influent-3	3	.26	83.	.0030
Final effluent-1	1			.0008
Final effluent-1	3	.07	.008	L.0001
Final effluent-2	1			.0013
Final effluent-2	3	.08	.024	.0060
Final effluent-3	1			.0009
Final effluent-3	3	.08	.002	.0040
Final effluent-3	3	.08		
Final effluent-composite	1			.0005
Refinery K				
Intake-1	2			
Intake-2	2	L.02	L.010	
Intake-3	2			
Intake-composite	2			L.0005
DAF effluent-1	2			
DAF effluent-2	2	L.02	.7	
DAF effluent-3	2			
DAF effluent-composite	2			L.0005
Final effluent-1	2			
Final effluent-2	2	L.02	.029	
Final effluent-3	2			
Final effluent-composite	2			L.0005

TABLE III-9 (Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery L				
Intake-1	2	L.06	L.010	
Intake-1	1			L.0001
Intake-2	2	L.06	L.010	
Intake-2	1			.0002
Intake-3	2	L.06	L.010	
Intake-3	1			.0002
Intake-composite	2			
Intake-composite	1			.0002
Separator-1 effluent-1	2	.19	51.	
Separator-1 effluent-1	1			.0014
Separator-1 effluent-2	2	.36	52.	
Separator-1 effluent-2	1			.0014
Separator-1 effluent-3	2	.58	61.	
Separator-1 effluent-3	1			.0008
Separator-1 effluent-composite	2			
Separator-1 effluent-composite	1			.0015
Separator-2 effluent-1	2	.16		
Separator-2 effluent-1	1			.0006
Separator-2 effluent-2	2	.21	22.	
Separator-2 effluent-2	1			.0004
Separator-2 effluent-3	2	.08	L2.6	
Separator-2 effluent-3	1			.0004
Separator-2 effluent-composite	2			
Separator-2 effluent-composite	1			.0005
Final effluent-1	2	.08	L.010	
Final effluent-1	1			.0003
Final effluent-2	2	.08	.010	
Final effluent-2	1			.0003
Final effluent-3	2	.08	L.010	
Final effluent-3	1			.0003
Final effluent-composite	2			
Final effluent-composite	1			.0003
Refinery M				
Intake-1	2	L.02	L.010	
Intake-2	2	L.02	L.010	
Intake-3	2	L.02	L.010	
Intake-composite	2			
DAF effluent-1	2	.01	4.7	
DAF effluent-2	2	.02	4.2	
DAF effluent-3	2	.03	4.3	
DAF effluent-composite	2			
Final effluent-1	2	L.02	L.010	
Final effluent-2	2	L.02	L.010	
Final effluent-3	2	L.02	L.010	
Final effluent-composite	2			

TABLE III-9 (Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery N				
Intake-1	2	L.06	L.010	
Intake-1	1			.0002
Intake-2	2	L.03	L.011	
Intake-2	1			.0001
Intake-3	2	L.06	L.010	
Intake-3	1			.0002
Intake-composite	2			L.0005
Intake-composite	1			.0002
Separator effluent-1	2	L.06	6.2	
Separator effluent-1	1			.0004
Separator effluent-2	2	.04	6.5	
Separator effluent-2	1			.0006
Separator effluent-3	2	L.06	4.7	
Separator effluent-3	1			.0004
Separator effluent-composite	2			L.0005
Separator effluent-composite	1			.0005
Chem plant effluent-1	2	L.06	L.260	
Chem plant effluent-1	1			L.0001
Chem plant effluent-2	2	L.03	.073	
Chem plant effluent-2	1			.0004
Chem plant effluent-3	2	L.06	.074	
Chem plant effluent-3	1			.0002
Chem plant effluent-composite	2			L.0005
Chem plant effluent-composite	1			.0002
Final effluent-1	2	L.06	L.015	
Final effluent-1	1			.0004
Final effluent-2	2	L.03	L.011	
Final effluent-2	1			.0002
Final effluent-3	2	L.06		
Final effluent-3	1			.0001
Final effluent-composite	2			L.0005
Final effluent-composite	1			.0001
Refinery O				
Intake-1	2	L.02	L.010	
Intake-2	2	L.02	L.005	
Intake-3	2	L.02	L.005	
Intake-composite	2			L.0005
DAF effluent-1	2	.21	11.	
DAF effluent-2	2	.16	10.	
DAF effluent-3	2	.13	11.	
DAF effluent-composite	2			L.0005
Final effluent-1	2	L.03	.052	
Final effluent-2	2	L.03	.049	
Final effluent-3	2	L.03	.036	
Final effluent-composite	2			L.0005

TABLE III-9 (Cont.)

Sample-Day[a]	Lab	Cyanide	Phenolics	Mercury
Refinery P				
Intake-1	2	L.03	L.010	
Intake-2	2	L.02	L.005	
Intake-3	2	L.02	L.005	
Intake-composite	2			L.0005
Separator effluent-1	2	.09	106.	
Separator effluent-2	2	.06		
Separator effluent-3	2	.04	29.	
Separator effluent-composite	2			L.0005
Final effluent-1	2	L.03	.012	
Final effluent-2	2	L.03	.011	
Final effluent-3	2	L.03	.010	
Final effluent-composite	2			L.0005
Refinery Q[c]				
Intake-1	1			.0021
Intake-1	3	L.01	L.001	
Intake-2	1			.0012
Intake-2	3	.02	.004	.0010
Intake-3	1			.0034
Intake-3	3	L.01	.010	.0060
Separator effluent-1	1			.0002
Separator effluent-1	3	L.01	.102	.0060
Separator effluent-1	3		.113	
Separator effluent-2	1			.0003
Separator effluent-2	3	L.01	.116	L.0002
Separator effluent-3	1			.0003
Separator effluent-3	3	.03	.118	L.0002
Final effluent-1	1			.0003
Final effluent-1	3	L.01	.016	.0060
Final effluent-1	3	L.01		.0120
Final effluent-1	3			.0002
Final effluent-2	1			.0003
Final effluent-2	3	.32	.018	.0020
Final effluent-2	3	.32	.018	L.0002
Final effluent-3	1			.0008
Final effluent-3	3	.01	.014	L.0002
Intake-4	3	L.02		L.0001
Separator effluent-4	3	L.02		L.0002
Final effluent-4	3	L.02		L.0001

Notes: (a) If a value is not listed for a particular sample location and time, then the indicated laboratory did not test that sample for the specified pollutant.
(b) L – less than.
(c) Grab samples collected during revisits to Refineries C, G, Q are indicated as Day 4.

Labs: 1 - EPA Region V Laboratory
2 - Robert S. Kerr Environmental Research Laboratory, EPA
3 - Ryckman, Edgerley, Tomlinson and Associates

TABLE III-10

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS FOR THE RSKERL AND B&R SAMPLING PROGRAM METALS (CONCENTRATIONS, ug/1)

Sample-Day[a]	Lab	Concentration (ug/1)											
		Ag	Be	Cd	Cr	Cu	Ni	Pb	Zn	As	Sb	Se	Tl
Refinery A													
I-1	1	L25	L2	L20	L24	L4	L50	L60	31				
I-2	1	L25	L2	L20	L24	L4	L50	L60	45				
I-3	1	L25	L2	L20	L24	L4	L50	L60	68				
I-Composite	1	L25	L2	L20	L24	L4	L50	L60	43				
I-Composite	2	L5	L3	L1	L5	L5	L15	L15	L10	L10	L25	L10	L25
SE-1	1	L25	L2	L20	L24	26	L50	147	253				
SE-2	1	L25	L2	L20	L24	23	L50	109	239				
SE-3	1	L25	L2	L20	1220	39	L50	224	329				
SE-C	1	L25	L2	L20	30	23	L50	114	272				
SE-C	2	L5	L3	L1	32	17	23	64	220	12	L25	L10	L15
FE-1	1	L25	L2	L20	L24	L4	L50	L60	64				
FE-2	1	L25	L2	L20	L24	L4	L50	L60	65				
FE-3	1	L25	L2	L20	L24	6	L50	L60	77				
FE-C	1	L25	L2	L20	L24	5	L50	L60	51				
FE-C	2	L5	L3	L1	5	L5	L15	L15	30	L10	L25	L10	L15
Refinery B													
I-1	1	L1	L1	L2	30	30	6	60	L60				
I-2	1	L1	L1	L2	30	20	6	60	L60				
I-3	1	2	L1	7	50	40	20	50	100				
I-C	1	2	L1	L2	60	30	20	70	100				
I-C	2	L5	L3	L1	L5	L5	L15	L15	15	L20	L25	L20	L15
DAF E-1	1	L1	L1	L2	50	L6	L5	L20	L60				
DAF E-2	1	L1	L1	L2	50	9	L5	L20	L60				
DAF E-3	1	L1	L1	3	60	10	L5	L20	L60				
DAF E-C	1	L1	L1	L2	60	10	L5	L20	L60				
DAF E-C	2	L5	L3	L1	L5	7	L15	L15	30	L20	L25	L20	L15
FE-1	1	L1	L1	8	70	L6	L5	L20	L60				
FE-2	1	L1	L1	L2	70	L6	L5	L20	L60				
FE-3	1	L1	L1	L2	40	L6	L5	L20	L50				
FE-C	1	L1	L1	L2	50	L6	L5	L20	L60				
FE-C	2	L5	L3	L1	L5	L5	L15	L15	25	L20	L25	L20	L15
Refinery C-1													
I-1	1	L25	L2	L20	L24	12	L50	L60	79				
I-1	3						L2	L1				4	L1
I-2	1	L25	L2	L20	L24	9	L50	L60	44				
I-2	3						L2	L1				13	3
I-3	1	L25	L2	L20	L24	11	L50	L60	109				
I-3	3						L2	L1				4	L1
I-C	1	L25	L2	L20	L24	21	L50	119	1450				
I-C	3	L1	L1	L1	2	2	1	1	20	4	1	5	L2
SE-1	1	L25	L2	L20	575	231	L50	71	607				
SE-1	3				770				630			11	L1
SE-2	1	L25	L2	L20	518	151	L50	L60	517				
SE-2	3				820				670			8	L1
SE-3	1	L25	L2	L20	669	140	L50	64	614				
SE-3	3				940				550			9	L1
SE-C	1	L25	L2	L20	574	182	L50	227	3420				
SE-C	3	L1	L1	L1	880	190	L1	12	690	8	L1	15	
TE-1	1	L25	L2	L20	133	27	L50	L60	527				
TE-1	3			13	940	100	9		930			10	L1
TE-2	1	L25	L2	L20	128	26	L50	66	489				
TE-2	3			9	470	190	6		440			L6	L1
TE-3	1	L25	L2	L20	770	51	L50	L60	881				
TE-3	3			15	1100	260	44		930			8	L1
TE-C	1	L25	L2	L20	342	59	L50	331	4780				
TE-C	3	L1	L1	16	490	230	18	17	780	6	1	15	
FE-1	1	L25	L2	L20	112	19	L50	L60	478				
FE-1	3						7	26	590			13	3
FE-2	1	L25	L2	L20	118	50	L50	113	565				
FE-2	3						7	58	620			10	7
FE-3	1	L25	L2	L20	142	24	L50	L60	526				
FE-3	3						7	26	590			19	L1
FE-C	1	L25	L2	L20	120	27	L50	112	1080				
FE-C	3	L1	L1	L1	3	10	15	50	700	5	3	19	L2
Refinery C-2[b]													
I	3								L1				L1
SE	3								679				L1
TE	3								519				L1
FE	3								543				L1

TABLE III-10 (Cont.)

Sample-Day[a]	Lab	Concentration (ug/l)											
		Ag	Be	Cd	Cr	Cu	Ni	Pb	Zn	As	Sb	Se	Tl
Refinery D													
I-1	1	L250	L20	L200	L240	L40	L500	L600	L250				
I-2	1	L250	L20	L200	L240	L40	L500	L600	L250				
I-3	1	L250	L20	L200	L240	L40	L500	L600	L250				
I-C	1	L250	L20	L200	L240	L40	L500	L600	L250				
I-C	2	L5	L3	L1	L14	L5	L15	L15	33	L10	L25	L10	L15
DAF E-1	1	L250	L20	L200	1020	L40	L500	L600	410				
DAF E-2	1	L25	L2	L20	681	15	L50	L60	242				
DAF E-3	1	L25	L2	L20	479	6	L50	L60	181				
DAF E-C	1	L25	L2	L20	719	7	L50	L60	262				
DAF E-C	2	L5	L3	L1	730	L5	L15	L15	280	L10	L25	L10	L15
FE-1	1	L25	L2	L20	1230	L4	L50	L60	515				
FE-2	1	L25	L2	L20	1160	L4	L50	L60	480				
FE-3	1	L25	L2	L20	875	L4	L50	L60	338				
FE-C	1	L25	L2	L20	1080	L4	L50	L60	430				
FE-C	2	15	L3	L1	1000	L5	L15	L15	400	L10	L25	L10	L15
Refinery E													
I-1	1	L25	L2	L20	25	5	L50	L60	141				
I-2	1	L25	L2	L20	58	8	L50	L60	102				
I-3	1	L25	L2	L20	35	15	L50	L60	130				
I-C	1	L25	L2	L20	42	10	L50	L60	127				
I-C	2	L5	L3	2	35	8	51	23	110	L10	L25	L10	L15
DAF E-1	1	L25	L2	L20	104	L4	L50	L60	61				
DAF E-2	1	L25	L2	L20	86	L4	L50	L60	47				
DAF E-3	1	L25	L2	L20	89	L4	L50	L60	54				
DAF E-C	1	L25	L2	L20	89	L4	L50	L60	74				
DAF E-C	2	L5	L3	L1	76	L5	28	L15	50	L10	L25	L10	L15
FE-1	1	L25	L2	L20	42	L4	L50	L60	49				
FE-2	1	L25	L2	L20	52	L4	L50	L60	77				
FE-3	1	L25	L2	L20	44	L4	L50	L60	59				
FE-C	1	L25	L2	L20	42	L4	L50	L60	44				
FE-C	2	L5	L3	L1	36	L5	19	L15	30	L10	L25	12	L15
Refinery F													
I-1	1	L250	L20	L200	L240	50	L500	L600	L250				
I-2	1	L250	L20	L200	L240	190	L500	L600	L250				
I-3	1	L250	L2	L20	72	184	57	L60	127				
I-C	1	L250	L2	L20	58	151	62	L60	133				
I-C	2	L5	L3	L1	60	210	58	L15	120	27	L25	12	L15
CT B-1	1	L250	L2	L20	50	278	64	L60	229				
CT B-2	1	L250	L2	L20	60	350	101	L60	342				
CT B-3	1	L25	L2	L20	79	510	134	L60	452				
CT B-C	1	L25	L2	L20	57	405	88	L60	342				
CT B-C	2	L5	L3	L1	44	500	77	L15	330	41	L25	L10	L15
FE-1	1	L25	L2	L20	73	199	68	L60	125				
FE-2	1	L25	L2	L20	31	86	74	L60	151				
FE-3	1	L25	L2	L20	29	84	71	L60	112				
FE-C	1	L25	L2	L20	45	125	64	L60	132				
FE-C	2	L5	L3	L1	7	125	58	L15	100	31	L25	L10	L15
Refinery G-1													
I-1	1	L25	L2	L20	L24	L4	L50	78	52				
I-1	3								L1				L1
I-2	1	L25	L2	L20	L24	L4	52	102	72				
I-2	3								L1				L1
I-3	1	L25	L2	L20	L24	L4	L50	L60	2[illegible]				
I-3	3								L1				L1
I-C	1	L25	L2	L20	L24	L4	L50	L60	30				
I-C	3	L1	L1	L1	1	7	L1	2	36	5	L1	3	L2
SE-1	1	L25	L2	L20	615	6	L50	181	125				
SE-1	3				820			420	60			9	L1
SE-2	1	L25	L2	L20	676	53	85	308	117				
SE-2	3				790			160	24			10	L1
SE-3	1	L25	L2	L20	73	L4	L50	L60	170				
SE-3	3				1200			430	110			6	L1
SE-C	1	L25	L2	L20	606	8	93	181	179				
SE-C	3	L1	L1	L1	1000	7	L1	278	66	5	L1	6	L2
DAF E-1	1	L25	L2	L20	526	L4	L50	159	93				
DAF E-1	3				710			270	44			5	L1
DAF E-2	1	L25	L2	L20	414	L4	L50	115	94				
DAF E-2	3				680			320	87			13	L1
DAF E-3	1	L25	L2	L20	73	L4	L50	L60	64				
DAF E-3	3				930			360	92			7	L1
DAF E-C	1	L25	L2	24	425	8	104	144	139				
DAF E-C	3	L1	L1	L1	800	3	1	260	53	L4	1	9	L2
FE-1	1	L25	L2	L20	89	L4	57	107	51				
FE-1	3											32	6
FE-2	1	L25	L2	L20	86	L4	63	90	46				
FE-2	3											9	12
FE-3	1	L25	L2	L20	73	L4	L50	L60	64				
FE-3	3											7	5
FE-C	1	L25	L2	L20	L24	L4	L50	L60	30				
FE-C	3	L1	L2	L1	1	7	L1	2	36	5	L1	3	L2

TABLE III-10 (Cont.)

		Concentration (ug/l)											
Sample-Day[a]	Lab	Ag	Be	Cd	Cr	Cu	Ni	Pb	Zn	As	Sb	Se	Tl
Refinery G-2[b]													
I	3												L1
BE	3												L1
DAF E	3												L1
FE	3												L1
Refinery H													
I-1	1	L1	L1	L2	20	L6	L5	L20	L60				
I-2	1	L1	L1	L2	10	9	L5	L20	L60				
I-3	1	L1	L1	8	20	10	L5	L20	L60				
I-C	1	L1	L1	L2	10	7	L5	L20	L60				
I-C	2	L5	L3	L1	L5	L5	L15	L15	15	L20	L25	L20	L15
SE-1	1	L1	L1	L2	10	30	L5	L20	L60				
SE-2	1	L1	L1	L2	7	20	L5	L20	L60				
SE-3	1	L1	L1	L2	20	30	L5	L20	70				
SE-C	1	L1	L1	L2	10	30	L5	L20	L60				
SE-C	2	L5	L3	L1	L5	7	L15	L15	30	L20	L25	L20	L15
FE-1	1	L1	L1	L2	20	10	L5	80	L60				
FE-2	1	L1	L1	L2	10	10	L5	30	60				
FE-3	1	L1	L1	20	10	9	L5	L20	L60				
FE-C	1	L1	L1	L2	10	7	L5	30	L60				
FE-C	2	L5	L3	L1	L5	L5	L15	L15	25	L20	L25	20	L15
Refinery I													
I-1	1	L25	L2	L20	L24	L4	L50	L60	69				
I-1	3												L1
I-2	1	L25	L2	L20	L24	6	L50	L60	52				
I-2	3												L1
I-3	1	L25	L2	L20	L24	20	L50	79	836				
I-3	3												L1
I-C	1	L25	L2	L20	L24	16	L50	78	536				
I-C	3	L1	L1	L1	1	10	L1	2	25	L4	L1	2	L1
SE-1	1	L25	L2	L20	98	157	L50	L60	172				
SE-1	3						7		110			L4	L1
SE-2	1	L25	L2	L20	91	167	L50	L60	237				
SE-2	3						L2		100			L4	L1
SE-3	1	L25	L2	L20	102	146	L50	90	1070				
SE-3	3						L2		100			7	L1
SE-C	1	L25	L2	L20	98	157	L50	168	1120				
SE-C	3	L1	L1	L1	3	6	5	2	100	5	L1	4	L2
FE-1	1	L25	L2	L20	L24	85	L50	L60	69				
FE-1	3											25	L1
FE-2	1	L25	L2	L20	L24	22	L50	L60	69				
FE-2	3											23	L1
FE-3	1												
FE-3	3												
FE-C	1	L25	L2	L20	L24	71	L50	211	2000				
FE-C	3	L1	L1	L1	1	3	L1	2	60	L4	L1	16	L2
Refinery J													
I-1	1	L25	L2	L20	L24	5	L50	L60	72				
I-1	3												L1
I-2	1	L25	L2	L20	L24	10	L50	L60	54				
I-2	3												L1
I-3	1	L25	L2	L20	L24	L4	L50	L60	62				
I-3	3												L1
I-C	1	L25	L2	L20	L24	4	L50	L60	62				
I-C	3	L1	L1	L1	1	1	1	2	54	3	L1	3	L2
S1 E-1	1	L25	L2	L20	36	L4	L50	L60	150				
S1 E-1	3								120			7	L1
S1 E-2	1	L25	L2	L20	620	1370	771	958	499				
S1 E-2	3				100				250			16	L1
S1 E-3	1	L25	L2	L20	50	33	L50	L60	432				
S1 E-3	3				16				420			L4	L1
S1 E-C	1	L25	L2	L20	52	25	L50	L60	257				
S1 E-C	3	L1	L1	L1	76	2	L1	4	320	3	L1	5	L2
S2 E-1	1	L25	L2	L20	440	L4	L50	190	316				
S2 E-1	3				450			190	290			16	3
S2 E-2	1	L25	L2	L20	1050	231	69	2080	1400				
S2 E-2	3				1100			2000	2100			12	L1
S2 E-3	1	L25	L2	L20	411	L4	L50	876	790				
S2 E-3	3				390			380	680			14	L1
S2 E-C	1	L25	L2	L20	584	55	61	810	658				
S2 E-C	3	L1	L1	L1	780	7	L1	870	740	5	L1	8	3
S3 E-1	1	L25	L2	L20	547	14	118	123	194				
S3 E-1	3				830				150			17	L1
S3 E-2	1	L25	L2	L20	1010	16	L50	L60	245				
S3 E-2	3				1200				210			13	L1
S3 E-3	1	L25	L2	L20	350	16	L50	L60	280				
S3 E-3	3				660				280			31	L1

TABLE III-10 (Cont.)

Sample-Day[a]	Lab	Concentration (ug/l)											
		Ag	Be	Cd	Cr	Cu	Ni	Pb	Zn	As	Sb	Se	Tl
Refinery J (Cont.)													
S3 E-C	1	L25	L2	L20	626	25	63	71	215				
S3 E-C	3	1	L1	L1	570	2	L1	2	260	3	L1	6	L2
S4 E-1	1	L25	L2	L20	835	38	L50	80	411				
S4 E-1	3				1500				340			25	L1
S4 E-2	1	L25	L2	L20	1210	21	L50	L60	261				
S4 E-2	3				1300				290			24	L1
S4 E-3	1	L25	L2	L20	1860	77	L50	L60	579				
S4 E-3	3				1700				620			4	L1
S4 E-C	1	L25	L2	L20	1300	42	L50	69	304				
S4 E-C	3	2	L1	L1	1900	10	L1	12	560	3	1	11	L2
S5 E-1	1	31	2	L20	1580	51	189	164	464				
S5 E-1	3			4	2200				600			7	L1
S5 E-2	1	L25	L2	L20	2790	47	L50	L60	609				
S5 E-2	3			5	4900				740			29	4
S5 E-3	1	L25	L2	L20	1500	51	L50	L60	417				
S5 E-3	3			9	1800				520			19	6
S5 E-C	1	L25	L2	L20	2010	45	79	101	491				
S5 E-C	3	L1	L1	7	3600	182	1	2	760	9	L1	23	L2
B-P I-1	1	L25	L2	L20	L24	41	L50	72	148				
B-P I-1	3				9							20	L1
B-P I-2	1	L25	L2	L20	L25	7	L50	L60	54				
B-P I-2	3				5							10	L1
B-P I-3	1	L25	L2	L20	L24	L4	L50	L60	65				
B-P I-3	3				6							18	L1
B-P I-C	1	L25	L2	L20	29	17	L50	L60	55				
B-P I-C	3	L1	L1	L1	22	2	L1	3		L2	L1	22	L2
FE-1	1	L25	L2	L20	96	9	53	82	130				
FE-1	3				150							20	L1
FE-2	1	L25	L2	L20	94	L4	L50	L60	51				
FE-2	3				27		7					27	L1
FE-3	1	L25	L2	L20	102	6	65	L60	46				
FE-3	3				27		6					16	L1
FE-C	1	L25	L2	L20	82	L4	L50	L60	62				
FE-C	3	L1	L1	L1	54	32	3	9	62	L4	L11	12	L2
Refinery K													
I-1	1	L1	L1	L2	20	10	L5	70	200				
I-2	1	L1	L1	L2	10	10	L5	40	70				
I-3	1	L1	L1	3	10	10	L5	80	60				
I-C	1	L1	L1	L2	20	10	L5	40	70				
I-C	2	L5	L3	L1	5	6	L15	L15	45	L20	L25	L20	L15
DAF E-1	1	L1	L1	L2	1000	200	9	50	1000				
DAF E-2	1	L1	L1	L2	2000	400	20	200	3000				
DAF E-3	1	L1	L1	L2	1000	200	L5	60	1000				
DAF E-C	1	L1	L1	L2	1000	300	20	100	2000				
DAF E-C	2	L5	L3	3	1600	280	28	70	1400	L20	L25	L20	L15
FE-1	1	L1	L1	L2	100	60	L5	L20	100				
FE-2	1	L1	L1	L2	60	10	L5	L20	70				
FE-3	1	L1	L1	L2	100	20	L5	L20	100				
FE-C	1	L1	L1	L2	100	30	L5	L20	1000				
FE-C	2	L5	L3	1	73	18	L15	L15	120	L20	L25	L20	L15
Refinery L													
I-1	1	L250	L20	L200	L240	L40	L500	L600	810				
I-2	1	L250	L20	L200	L240	L40	L500	700	L250				
I-3	1	L25	L2	L20	L24	22	L50	64	125				
I-C	1	L250	L20	L200	L240	L40	L500	L600	L250				
I-C	2	L5	L3	L1	30	20	21	40	120	L20	L25	L20	L15
S1 E-1	1	L250	L20	L200	1000	170	L500	L600	490				
S1 E-2	1	L250	L20	L200	L240	L40	L500	L600	290				
S1 E-3	1	L250	L20	L200	L240	100	L500	L600	290				
S1 E-C	1	L250	L20	L200	L240	100	L500	L600	360				
S1 E-C	2	L5	L3	L1	290	180	70	45	370	L20	L25	L20	L15
S2 E-1	1	L25	L2	L20	773	43	L50	L60	382				
S2 E-2	1	L25	L2	L20	831	54	L50	L60	304				
S2 E-3	1	L25	L2	L20	928	31	L50	L60	314				
S2 E-C	1	L25	L2	L20	802	42	L50	L60	325				
S2 E-C	2	L5	L3	L1	870	50	16	17	290	L20	L25	L20	L15
FE-1	1	L25	L2	L20	205	24	L50	L60	174				
FE-2	1	L25	L2	L20	119	19	L50	L60	157				
FE-3	1	L25	L2	L20	165	31	L50	L60	161				
FE-C	1	L25	L2	L20	144	24	L50	L60	174				
FE-C	2	L5	L3	L1	190	39	15	L15	140	L20	L25	L20	L15

TABLE III-10 (Cont.)

Sample-Day [a]	Lab	Concentration (ug/l)											
		Ag	Be	Cd	Cr	Cu	Ni	Pb	Zn	As	Sb	Se	Tl
Refinery M													
I-1	1	L1	L1	L2	30	300	10	200	200				
I-2	1	L1	L1	L2	10	100	L5	L20	90				
I-3	1	L1	L1	L2	20	100	L5	40	100				
I-C	1	L1	L1	L2	20	200	L5	60	100				
I-C	2	L5	L3	L1	L5	180	L15	25	75	L20	L25	L20	L15
DAF E-1	1	L1	2	L2	200	10	L5	L20	200				
DAF E-2	1	L1	2	L2	100	10	L5	L20	100				
DAF E-3	1	L1	2	L2	90	9	L5	L20	90				
DAF E-C	1	L1	2	L2	100	10	L5	L20	100				
DAF E-C	2	L5	L3	L1	73	6	L15	L15	140	L20	L25	L20	L15
FE-1	1	L1	2	3	90	10	L5	L20	90				
FE-2	1	L1	2	L2	100	10	L5	50	100				
FE-3	1	4	L1	L2	90	20	10	L20	100				
FE-C	1	4	L1	L2	100	20	20	30	200				
FE-C	2	L5	L3	L1	24	8	L15	L15	90	L20	L25	L20	L15
Refinery N													
I-1	1	L25	L2	L20	L24	L4	L50	L60	56				
I-2	1	L25	L2	L20	L24	L4	L50	L60	29				
I-3	1	L250	L20	L200	3000	L40	790	L600	L250				
I-C	1	L25	L2	L20	L24	L4	L50	L60	36				
I-C	2	L5	L3	L1	7	L5	L15	L15	19	L20	L25	L20	L15
SE-1	1	L250	L20	L200	1000	L40	L500	L600	480				
SE-2	1	L250	L20	L200	2000	L40	L500	L600	760				
SE-3	1	L25	L2	L20	980	7	L50	L60	573				
SE-C	1	L25	L2	L20	1280	14	L50	L60	603				
SE-C	2	L5	L3	L1	1400	61	16	18	570	L20	L25	L20	L15
CPE-1	1	L25	L2	L20	805	L4	L50	L60	6520				
CPE-2	1	L25	L2	L20	679	8	L50	L60	4110				
CPE-3	1	L25	L2	L20	499	7	L50	L60	4260				
CPE-C	1	L25	L2	L20	701	L4	L50	L60	5210				
CPE-C	2	L5	L3	L1	650	13	L15	L15	4800	L20	L25	L20	L15
FE-1	1	L25	L2	L20	L24	L4	L50	L60	L25				
FE-2	1	L25	L2	L20	159	L4	L50	L60	118				
FE-3	1	L25	L2	L20	131	L4	L50	L60	61				
FE-C	1	L25	L2	L20	137	L4	L50	L60	104				
FE-C	2	L5	L3	L1	120	11	L15	L15	35	L20	L25	L20	L15
Refinery O													
I-1	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-2	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-3	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-C	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-C	2	L5	L3	L1	8	L5	L15	L15	L10	L20	L25	L20	L15
DAF E-1	1	L1	L1	L2	200	30	L5	L20	L60				
DAF E-2	1	L1	L1	L2	300	10	L5	L20	L60				
DAF E-3	1	L1	L1	L2	300	8	L5	L20	100				
DAF E-C	1	L1	L1	L2	200	20	L5	L20	60				
DAF E-C	2	L5	L3	L1	240	30	L15	27	74	L20	L25	L20	L15
FE-1	1	L1	L1	L2	50	L6	L5	L20	L60				
FE-2	1	L1	L1	L2	50	L6	L5	L20	L60				
FE-3	1	L1	L1	L2	50	L6	L5	L20	L60				
FE-C	1	L1	L1	L2	50	L6	L5	L20	L60				
FE-C	2	L5	L3	L1	110	L5	L15	L15	L10	L20	L25	L20	L15
Refinery P													
I-1	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-2	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-3	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-C	1	L1	L1	L2	L5	L6	L5	L20	L60				
I-C	2	L5	L3	L1	40	L5	L15	L15	61	L20	L25	L20	L15
SE-1	1	L1	L1	L2	900	L6	L5	L20	L60				
SE-2	1	L1	L1	L2	50	L6	L5	L20	L60				
SE-3	1	L1	L1	L2	700	L6	L5	L20	L60				
SE-C	1	L1	L1	L2	600	L6	L5	L20	L60				
SE-C	2	L5	L3	L1	72	L5	L15	L15	55	L20	360	L20	L15
FE-1	1	L1	L1	L2	L5	L6	L5	L20	L60				
FE-2	1	L1	L1	L2	L5	L6	L5	L20	L60				
FE-3	1	L1	L1	L2	L5	L6	L5	L20	L60				
FE-C	1	L1	L1	L2	L5	L6	L5	L20	L60				
FE-C	2	L5	L3	L1	40	L5	L15	L15	43	L20	370	L20	L15

TABLE III-10 (Cont.)

Sample-Day[a]	Lab	Concentration (ug/l) Ag	Be	Cd	Cr	Cu	Ni	Pb	Zn	As	Sb	Se	Tl
Refinery Q-1													
I-1	1	L25	L2	L20	L24	37	L50	L60	70				
I-1	3											L6	L1
I-2	1	L25	L2	L20	L24	37	L50	L60	62				
I-2	3											6	L1
I-3	1	L25	L2	L20	L24	20	L50	L60	329				
I-3	3											10	L1
I-C	1	L25	L2	L20	L24	53	L50	167	2820				
I-C	3	L1	L1	L1	1	120	L1	2	35	7	L1	6	L2
SE-1	1	L25	L2	L20	L24	7	L50	L60	274				
SE-1	3					60			330	480		9	L1
SE-2	1	L25	L2	L20	L24	L4	L50	L60	444				
SE-2	3					140			470	460		7	L1
SE-3	1	L25	L2	L20	L24	6	L50	L60	511				
SE-3	3					60			640	460		6	L1
SE-C	1	L25	L2	L20	L24	15	L50	101	1460				
SE-C	3	L1	L1	L1	1	210	L1	10	470	440	L1	10	L2
FE-1	1	L25	L2	L20	L24	11	L50	L60	245				
FE-1	3								380	790		11	L1
FE-2	1	L25	L2	L20	L24	20	L50	L60	329				
FE-2	3			L1					360	900		10	L1
FE-3	1	L25	L2	L20	L24	6	L50	L60	300				
FE-3	3			L1					350	680		22	L1
FE-C	1	L25	L2	L20	L24	23	L50	102	1270				
FE-C	3	L1	L1	5	2	180	L1	15	340	800	1	20	L2
Refinery Q-2[b]													
IE	3					240			L1	35			
SE	3					380			262	350			
FE	3					300			167	500			

Notes: a) If a value is not listed for a particular sample location and time, then the indicated laboratory did not test that sample for the specified pollutant.

b) These data represent results from one-time grab samples collected during revisits to Refineries C, G, Q.

L - Less than
I - Intake
SE - Separator effluent
DAF E - DAF effluent
TE - Treated effluent
FE - Final effluent
CT B - Cooling Tower blowdown
B-P I - Bio-pond influent
CPE - Chemical plant effluent

Labs: 1 - EPA Region V Laboratory
2 - Robert S. Kerr Environmental Research Laboratory, EPA
3 - Ryckman, Edgerley, Tomlinson and Associates

TABLE III-11

Analytical Results for Traditional Parameters in the Pretreatment Sampling Program - Week 1

Sampling Location	Day	pH	SS mg/l	Sulfide mg/l S	BOD_5 mg/l	COD mg/l	CN mg/l	Phenol mg/l	O&G mg/l	Cr^{+6} mg/l	NH_3-N mg/l N
1. Refinery No. 25 Effluent	1	8.9	19	< 0.1	310	690	3.0	123	41.4	0.26	39.1
	2	8.7	45	< 0.1	320	710	2.6	88	42.3	0.48	36.1
	3	8.68	25	< 0.1	355	700	3.0	99	61.8	0.22	36.4
2. POTW No. 1	1	7.50	316	0.25	212	505	0.1	1.7	54.1	< 0.02	22.6
a. Raw Influent	2	7.50	290	0.20	240	580	*	*	59.0	< 0.02	26.3
	3	7.30	524	0.40	235	580	0.02	0.113	22.4	< 0.02	23.2
b. Final Effluent	1	7.40	1	< 0.1	3	34	0.06	0.003	1.3	< 0.02	8.8
	2	7.55	2	< 0.1	4	30	0.07	0.011	1.0	< 0.02	12.0
	3	7.80	2	< 0.1	5	35	0.05	0.012	0.9	< 0.02	9.7
c. Primary Sludge	1	5.9	21,200	35.0	> 4,930	28,600	0.24	2.30	2,660	< 0.02	74.2
	2	8.5	39,160	110.0	8,920	39,700	*	*	5,260	< 0.02	51.7
	3	6.78	12,450	33.0	1,230	30,100	0.05	0.622	1,044	< 0.02	31.8
d. Secondary Sludge	1	7.3	1,948	0.25	745	2,070	0.15	0.074	29.5	< 0.02	10.4
	2	7.45	3,536	0.80	1,460	42,300	*	*	59.5	< 0.02	10.7
	3	7.60	3,000	0.50	5,680	15,800	0.17	0.169	42.0	< 0.02	6.1

NOTE: Day 1 - 8/16/78; Day 2 - 8/17/78; Day 3 - 8/18/78

* in trace, but below detection limit

All samples were analyzed by the Water Quality Labs associated with POTW No. 1.

TABLE III-12

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS FOR THE PRETREATMENT SAMPLING PROGRAM-WEEK 1, VOLATILE ORGANIC CONCENTRATIONS, ug/l

Pollutant	Pol No.	Day	Ref.No.[x] 25 Eff.to POTW	POTW[x] Inf.	Primary[x] Eff.	Secondary[x] Eff.	Final[x] Eff.	Primary[xx] Sludge	Secondary[xx] Sludge
Benzene	4	1	4,200	23	17	-	-	9	-
		2	5,800	81	64	-	-	13	-
		3	1,600	*	14	-	-	-	-
Chlorobenzene	7	1	-	-	-	-	-	-	-
		2	31	-	-	-	-	-	-
		3	-	-	-	-	-	-	-
1,1,1-trichloro-ethane	11	1	-	5	-	-	-	-	-
		2	-	22	16	-	-	-	-
		3	-	*	10	-	15	-	-
1,1-dichloro-ethane	13	1	-	-	-	-	-	16	-
		2	-	*	-	-	-	-	-
		3	-	-	-	-	-	-	-
Chloroform	23	1	-	-	-	-	-	-	-
		2	21	10	*	-	*	-	-
		3	17	*	*	*	*	-	-
1,2-trans-dichloroethylene	30	1	-	-	-	-	-	60	-
		2	-	-	-	-	-	-	-
		3	-	*	*	-	-	50	-
Ethylbenzene	38	1	9,000	25	38	*	-	50	-
		2	5,600	20	25	-	*	20	-
		3	4,000	*	*	-	-	-	-
Methylene chloride	44	1	-	*	*	*	*	30	10
		2	-	*	*	*	-	(11) *	120
		3	-	*	*	*	23	(11) *	18(15)
Tetrachloro-ethylene	85	1	*	88	43	*	*	-	-
		2	-	117	160	16	10	-	-
		3	18	19	24	*	23	-	-
Toluene	86	1	15,000	84	67	-	-	30	-
		2	9,900	103	110	-	-	30	-
		3	5,700	24	31	-	-	10	-
Trichloro-ethylene	87	1	-	38	21	*	*	150	-
		2	-	57	78	*	*	-	7
		3	-	27	36	*	*	20	-

NOTE:
- - Not detected.
- * In traces, but below detection limit.
- ( ) Sample blank. No volatile organics detected in other sample blanks.
- x Analysis performed by West Coast Technical Service.
- xx Analysis performed by Pomeroy, Johnston and Bailey.

Of the 30 volatile organics, only 11 were detected.

TABLE III-13

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS FOR THE PRETREATMENT SAMPLING PROGRAM-WEEK 1, SEMIVOLATILE ORGANICS (CONCENTRATIONS, ug/l)

Pollutants	Poll No.	**	Day	Ref.No.^{x} 25 Eff.to POTW	POTW^{x} Inf.	Primary^{x} Eff.	Secondary^{x} Eff.	Final^{x} Eff.	Primary^{xx} Sludge	Secondary^{xx} Sludge
2,4-Dimethyl-phenol	34	AE	1	1,700	69	72	*	*	-	-
			2	-	-	-	*	-	-	-
			3	233	25	34	-	-	-	-
Pentachloro-phenol	64	AE	1	-	-	-	-	*	-	-
			2	-	-	-	*	*	-	-
			3	830	-	-	-	-	-	-
Phenol	65	AE	1	2,900	575	520	*	*	-	-
			2	-	700	700	*	*	355	405
			3	-	980	1,100	*	*	180	1,200
1,2 dichloro-benzene	25	BNE	1	-	*	-	*	*	13	20
			2	-	4	17	*	-	7	9
			3	-	15	11	*	*	10	-
1,3 dichloro-benzene	26	BNE	1	-	*	-	-	*	30	-
			2	-	19	17	*	-	15	5
			3	-	10	11	*	*	-	-
1,4 dichloro-benzene	27	BNE	1	-	28	23	*	*	30	-
			2	-	29	30	*	-	15	5
			3	-	24	30	10	*	9	-
Isophorene	54	BNE	1	-	-	-	-	-	-	-
			2	-	-	23	-	-	-	-
			3	-	-	-	-	*	-	-
Naphthalene	55	BNE	1	620	113	93	*	*	440	-
			2	-	121	156	*	-	30	-
			3	370	20	35	-	*	-	-
Nitrobenzene	56	BNE	1	-	-	-	-	-	5	-
			2	-	-	-	-	-	-	-
			3	-	-	-	-	-	-	-
Bis(2-ethyl-hexyl)phthalate	66	BNE	1	-	124	94	*	-	-	75
			2	-	112	56	*	*	130	180
			3	-	130	150	-	-	240	140
Butyl benzyl phthalate	67	BNE	1	16	55	59	-	-	170	-
			2	-	63	43	-	-	25	-
			3	-	39	68	*	*	14	-

TABLE III-13 (Continued)

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS FOR THE PRETREATMENT SAMPLING PROGRAM-WEEK 1, SEMIVOLATILE ORGANICS (CONCENTRATIONS, ug/1)

Pollutants	Poll No.	**	Day	Ref.No.[x] 25 Eff.to POTW	POTW Inf.[x]	Primary Eff.[x]	Secondary Eff.[x]	Final Eff.[x]	Primary Sludge[xx]	Secondary Sludge[xx]
Di-n-butyl Phthalate	68	BNE	1	40	24	19	*	*	-	-
			2	*	28	21	*	-	-	-
			3	-	34	17	*	*	-	-
Di-n-octyl Phthalate	69	BNE	1	-	12	*	-	-	-	-
			2	-	-	*	-	-	-	-
			3	-	-	-	-	-	-	-
Diethyl Phthalate	70	BNE	1	-	-	27	-	*	190	5
			2	14	13	17	*	-	-	-
			3	-	*	*	15	*	-	11
Dimethyl Phthalate	71	BNE	1	-	-	*	-	*	9	-
			2	-	-	*	-	-	-	-
			3	-	-	-	*	*	-	-
Acenaphthylene	77	BNE	1	-	-	-	-	-	-	-
			2	-	-	-	-	-	-	-
			3	-	-	*	-	-	-	-
Anthracene[+]	78	BNE	1	60	*	*	-	-	-	-
			2	51	*	*	-	-	-	-
			3	30	*	*	-	*	-	-
Fluorene	80	BNE	1	-	-	-	-	*	-	-
			2	63	*	*	-	-	-	-
			3	32	*	-	-	-	-	-
Phenanthrene[+]	81	BNE	1	60	*	*	-	-	-	-
			2	51	*	*	-	-	-	-
			3	30	*	*	-	*	-	-
Pyrene	84	BNE	1	-	-	-	-	-	-	-
			2	21	-	-	-	-	-	-
			3	-	-	-	-	-	-	-

Of 59 semi-volatile organics, only 20 were detected.

* in traces, but below Detection Limit.

** AE - Acid extractable; BNE - Base/neutral extractables.

+ Anthracene and Phenanthrene are unresolved.

- Not detected.

x Samples were analyzed by West Coast Technical Services.

xx Samples were analyzed by Pomeroy, Johnston and Bailey.

TABLE III-14

ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS FOR THE PRETREATMENT SAMPLING PROGRAM-WEEK 1, PESTICIDES(CONCENTRATIONS, ug/1)

Pollutant	Poll. No.	Day	Refinery^{x} No.23 Eff.to POTW	POTW^{x} Inf.	Primary^{x} Eff.	Secondary^{x} Eff.	Final^{x} Eff.	Primary^{xx} Sludge	Secondary^{xx} Sludge
4,4'-DDE	93	1	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-
		3	-	0.68	0.39	-	-	-	-
Heptachlor	100	1	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-
		3	-	0.12	0.13	-	-	-	-
b-BHC-Beta	103	1	0.18	-	-	-	-	-	-
		2	-	-	-	-	-	-	-
		3	0.10	0.55	0.49	-	-	-	-
r-BHC-Gamma	104	1	-	-	-	-	1.1	-	-
		2	-	-	6.3	-	1.2	-	-
		3	-	0.14	0.13	-	-	-	-

NOTE: Of 25 pesticides only 4 were found; none of the four were confirmed by GCMS.

- Not detected.

x Samples were analyzed by West Coast Technical Service.

xx Samples were analyzed by Pomeroy, Johnston and Bailey.

Table III-15

Analytical Results for Priority Pollutants for the Pretreatment Sampling Program - Week 1, Metals (Concentrations, ug/l)

			POTW No. 1						Effluent to POTW from Refinery No.
Pollutant	Poll. No.	Day	Influent x	Primary Effluent x	Secondary Effluent x	Final Effluent x	Primary Sludge xx	Secondary Sludge xx	25 x
Antimony	114	1	-	-	-	-	1250	830	-
		2	-	-	-	-	830	210	-
		3	-	-	-	-	60	23	-
Arsenic	115	1	27	-	-	-	86	73	30
		2	-	28	-	-	174	76	-
		3	26	-	-	-	66	60	-
Beryllium	117	1	-	-	-	-	12	6	-
		2	-	-	-	-	-	-	-
		3	-	-	-	-	4	10	-
Cadmium	118	1	61	37	-	-	1590	240	-
		2	29	20	-	-	610	320	-
		3	42	20	-	-	180	310	-
Chromium	119	1	335	197	39	18	17900	4080	1994
		2	357	188	33	16	17900	5560	1473
		3	241	140	31	15	2870	5140	1649
Copper	120	1	263	161	56	34	7800	2500	29
		2	248	132	16	-	11200	3300	26
		3	202	106	16	32	3300	3000	15
Lead	122	1	251	148	37	29	15700	1200	28
		2	218	105	-	-	9000	1500	26
		3	324	141	39	38	2800	1600	30
Mercury	123	1	-	-	1.48	0.52	14	17	-
		2	1.50	-	0.41	1.06	253	23	-
		3	0.41	0.44	0.38	0.51	46	20	-
Nickel	124	1	204	190	90	81	3220	710	-
		2	123	89	89	86	3400	850	-
		3	92	73	68	69	700	750	-
Selenium	125	1	31	30	-	-	-	-	193
		2	38	41	-	-	6	6	322
		3	32	-	30	35	-	9	267
Silver	126	1	-	-	-	-	80	50	-
		2	11	-	-	-	80	60	-
		3	11	-	-	-	60	60	-
Thallium	127	1	-	-	-	-	20	20	-
		2	-	-	-	-	80	-	-
		3	-	-	-	-	70	10	-
Zinc	128	1	836	492	122	58	40000	6100	155
		2	911	462	93	64	15800	8400	119
		3	857	449	143	69	6340	8040	171

Notes:
- Not Dectected
x Analyzed by EPA Region IV Laboratory
xx Analyzed by Pomeroy, Johnston and Bailey

TABLE III-16

Analytical Results for Traditional Parameters for the Pretreatment Sampling Program-Week 2, mg/l

Sampling Location	Day	pH	SS	Sulfide as S	BOD_5	COD	CN	Phenol	O & G	Cr^{+6}	NH_3-N as N
1. **Effluent to POTW from Refinery No.**											
a. No. 13	1	10.80	84	<0.1	450	972	0.13	51	774	<0.02	25.0
	2	10.00	86	0.1	402	789	0.14	60.6	83.6	<0.02	27.1
	3	11.42	56	<0.1++	361	764	0.34	106	13.9	<0.02	24.1
b. No. 21	1	8.75	20	<0.1	83	289	0.01	1.2	36	<0.02	2.1
	2	8.56	26	<0.1	202	441	0.02	2.1	34.5	<0.02	3.8
	3	8.65	24	<0.1++	90	322	0.03	1.1	32.7	<0.02	5.1
c. No. 45	1	7.32	22	<0.1	169	506	4.0	20	21.2	<0.02	161
	2	6.90	24	<0.1++	159	395	4.0	14.3	11.7	<0.02	92.0
	3	7.13	6	<0.1++	132	386	8.0	14.8	10.9	<0.02	57.5
d. No. 43 Direct Dis	1	8.24	14	<0.1	46	149	0.03	0.21	4.0	0.06	4.0
	2	7.60	36	<0.1++	57	130	0.01	0.04	3.8	<0.02	2.9
	3	7.29	36	<0.1++	12	111	0.05	0.06	3.1	<0.02	2.0
No. 43	1	7.68	58	<0.1	508	1,770	3.0	133	144	<0.02	32.0
	2	7.84	30	<0.1	528	2,430	8.0	151	142	<0.02	41.0
	3	7.52	8	<0.1++	556	3,330	9.0	148	117	<0.02	56.5
e. No. 16	1	7.51	29	<0.1	89	398	0.08	3.6	24.9	<0.02	20.5
	2	7.10	23	<0.1++	102	517	0.09	3.2	35.3	<0.02	30.4
	3	8.13	14	<0.1++	168	537	0.03	4.3	52.2	<0.02	22.7
2. **POTW No. 2**											
a. Influent	1	7.50	390	1.0	311	794	0.06	2.64	113	<0.02	35.8
	2	7.57	324	1.4	330	752	0.09	3.01	82	<0.02	40.5
	3	7.51	552	0.8	324	834	0.26	3.81	82	<0.02	35.1
b. Primary Effluent	1	7.50	82	0.2	190	437	0.05	3.16	29.3	<0.02	36.9
	2	7.58	112	0.2	198	420	0.11	3.11	32.3	<0.02	40.0
	3	7.51	92	0.1	180	450	0.44	4.35	34.7	<0.02	33.0
c. Final Effluent	1	7.68	188	0.6	181	539	0.06	2.79	38.7	<0.02	39.1
	2	7.77	184	0.4	203	502	0.11	3.07	47.3	<0.02	43.9
	3	7.55	232	0.4	187	603	0.44	4.14	52.0	<0.02	37.5
d. UNOX Influent	1	7.51	78	0.1	188	447	0.07	2.99	28.0	<0.02	32.1
	2	7.71	82	0.2	195	406	0.16	4.00	34.0	<0.02	37.9
	3	7.20	791	0.8	278	1,280	0.09	4.29	29.0	<0.02	34.0
e. UNOX Effluent	1	6.91	7	<0.1	3	61	0.06	<0.01	1.1	<0.02	35.9
	2	6.98	16	<0.1	6	86	0.05	0.03	3.1	<0.02	34.9
	3	7.00	9	<0.1	6	86	0.04	<0.01	1.0	<0.02	29.1
f. Primary Sludge	1	6.38	43,510	0.3	14,200	60,500	2.2	2.67	3,100	<0.02	39.9
	2	6.00	39,220	0.5	14,950	41,500	1.9	3.94	6,580	<0.02	40.1
	3	+	+	+	+	+	+	+	+	+	+
g. Digested Sludge	1	7.20	28,210	0.3	3,100	28,400	2.6	1.27	2,420	<0.02	870
	2	7.01	27,254	0.1	3,270	26,700	2.6	1.00	2,640	<0.02	436
	3	+	+	+	+	+	+	+	+	+	+
h. Centrate	1	7.59	13,970	0.4	2,060	17,500	1.5	0.88	1,660	<0.02	414
	2	7.58	13,940	0.2++	2,350	16,600	1.8	0.77	1,680	<0.02	420
	3	+	+	+	+	+	+	+	+	+	+

NOTE: Day 1 - 8/23/78; Day 2 - 8/24/78; Day 3 - 8/25/78. All samples were analyzed by the Water Quality Labs associated with POTW No. 2. Analyses for CN, Phenols and O & G were determined on grab samples. Remaining constituents were determined on 24 hour composites.

+ Not sampled

++ Zinc Acetate added to remove interferences

TABLE III 17

Analytical Results of Priority Pollutants for the Pretreatment Sampling Program - Week 4, Volatile Organics (Concentrations, ug/l)

Pollutant	Poll No.	Day **	POTW No. 2 * Inf	POTW No. 2 Primary* Eff.	POTW No. 2 Unox* Inf	POTW No. 2 Unox* Eff	POTW No. 2 Final* Eff	POTW No. 2 ** Centrate	POTW No. 2 ** Primary Sludge	POTW No. 2 ** Digested Sludge	POTW No. 2 ** Filter Cake (mg/kg)	Effluent to POTW from Refinery No. 13*	21*	45*	43x Direct	43x	16*
Benzene	4	1	62	71	79			-	40	17	6		1200	226	-	*	380
		2	57	67	77	*	62					*	*	240	*	47	140
		3	24	27	45	-	31	35	130	19	-	349	198	319	-		
Carbon Tetra-Chloride	6	1	-	-	-			-	5	-	-		-	-	-	-	-
		2	111	-	-	-	-					-	-	-	-	-	-
		3	100	-	-	-	184	-	6	-		-	-	-	-		-
Chlorobenzene	7	1	-	-	-			-	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-					-		-	-		
		3	-	-	*	-	-	-	-	-	-			-	-	-	-
1,2-dichloroethane	10	1	30	30	-			-	7	12	5			-	*	-	-
		2	-	19	-	-	14					-	54	-	18	-	-
		3	500	714	-	*	621	11	-	-	-	*	33	-	24		
1,1,1-trichloro-ethane	11	1	200	98	306			-	-	-	-		-	-	-	-	-
		2	535	95	159	231	97					14	-	-	-	15	-
		3	230	252	482	170	164		50	-		*	-	-	*		
1,1-dichloroethane	13	1	-	-	*			-	30	6	-		-	-	-	-	-
		2	-	-	-	*	-						-	-	-	-	-
		3	-	-	*	11	*	10	25	12	-	-	-	-	-		
1,1,2,2-tetrachloro ethane	15	1	-	-	-			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	51					-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-	-	-	-	-		
Chloroform	23	1	13	13	10			-	13	-	-		18	*	*	-	*
		2	11	14	12	15	12					9	21	*	*	-	-
		3	21	111	14	14	19	-	-	-	-	*	19	*	*		
1,1-dichloro-ethylene	29	1	*	-	*				-	-	-		-	-	-	-	-
		2	30	-	-	-						-	-	-	-	-	-
		3	-	-	12	16	-	-	-	30	-	-	-	-	-		
1,2-trans-dichloro Ethylene	30	1	-	-				-				5	-	-	-	-	-
		2	-	-	-	-	-	25		-		-	-	-	-		
		3	-	-	-	-	-	-		-			-	-	-	-	-
1,2-dichloro propylene	32	1	-	-	-				-	-	-	-	-	-	-	-	-
		2	-	-	3	-	-					-	-	-	-		
		3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	38	1	33	41	41			-	70	55	25		18000	108	-	-	381
		2	39	51	47	*	53					*	*	130	-	-	170
		3	53	46	37	-	48	35	150	75	15	410	220	76			
Methylene Chloride	44	1	24	44	67			(6)*	(7)*450	-	-		*	-	-	12	-
		2	221	15	11	-	44					-	-	-	-	-	-
		3	37	14	-	-	40	-	540	6	11	-	-	-	-		
dichloro bromo methane	48	1	-	-	-			-		-	-		-	-	-	-	-
		2	-	-	-	*	-					-	-	-	-	-	-
		3	-	-	-	*	-	-		-	-	-	-	-	-		
chloro dibromo methane	51	1	-		-				-	-		-	-	-	-	-	-
		2	-	-	*		-					-	-	-	-	-	-
		3	-	-	-	-	-	-	9	-	-	-	-	-	-		
tetra chloro ethylene	85	1	73	70	85							-	-	-	-	-	-
		2	64	65	67	129							-	-	-		
		3	63	61	98	131	70						-	-	-		
Toluene	86	1	161	197	202				140	60(c)	15		40000	420	-	*	870
		2	127	156	174	*						*	*	430	*	*	370
		3	61	72	86		80	65	360	75	8	4600	7500	457	-		
trichloroethylene	87	1	12	15	29			-	250	-	-	-	-	-	*	-	-
		2	14	21	76	22									*	-	-
		3	12	12	24	*	15	-	300	10	-			-	*		

NOTE: - not detected; * in traces but below detection limit; ( ) sample blank. No volatile organics detected for other sample blanks; x = analysis performed by [illegible]; ** = analysis performed by Pomeroy, Johnston & Bailey; [illegible] Nos. 15, 24 and 25 of 1978.

TABLE VII-18

ANALYTICAL RESULTS OF PRIORITY POLLUTANTS FOR THE PRETREATMENT SAMPLING PROGRAM - WEEK 2

SEMIVOLATILE ORGANICS CONCENTRATIONS, ug/l

Pollutant	**	Poll No.	Day	POTW No. 2									Effluent to POTW from Refinery No.					
				Inf.*	Tkl.g Eff.	Unox Inf.	Unox Eff.	Final Eff.*	Centrate**	Pri. Sludge**	Dig. Sludge**	Filter Cake** (ug/kg)	13X	21X	45X	Direct	43A	16X
Parachlorometacresol	AE	22	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	-	-	96	-	-	-	-	-	-	-	-		
2-Chlorophenol	AE	24	1	-	-	-			-	-	-	-		*	-	-	-	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	-	-		
2,4-dimethylphenol	AE	34	1	300	-	317			-	-	-	-		202	459	-	599	385
			2	220	230	210	-	180					1300	430	720	*	9300	250
			3	720	750	470	-	740	-	-	-	-	3600	550	2000	16		
Pentachlorophenol	AE	64	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					-	-	-	-	-	*
			3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Phenol	AE	65	1	700	840	620			7300	470	1900	-		218	4200	-	-	944
			2	150	210	190	*	160					1100	63	1000	-	14,000	185
			3	840	600	420	*	660	4600	-	1300	-	3200	119	2200	-		
Acenaphthene	BNE	1	1	*	*	-			-	-	-	-		-	17	*	-	-
			2	-	-	-	-	-					18	-	41	*	-	-
			3	*	*	-	-	-	-	-	-	-	-	-	*	*		
1,2,4-trichloro benzene	BNE	8	1	*	29	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	*	-					-	-	-	-	-	-
			3	20	-	-	-	-	-	-	-	-	-	-	-	-		
1,2 dichlorobenzene	BNE	25	1	48	57	24			85	35	30	-		-	-	-	-	-
			2	27	32	32	*	12					-	-	-	-	-	-
			3	13	14	14	-	22	170	135	245	45	-	-	-	-		
1,3-dichlorobenzene	BNE	26	1	*	*	*			55	40	25	-		-	-	-	-	-
			2	20	*	*	-	*					-	-	-	-	-	-
			3	12	*	*	21	-	-	-	-	-	-	-	-	-	-	-
1,4-dichlorobenzene	BNE	27	1	17	17	12			55	40	25	-		-	-	-	-	-
			2	20	16	17	*	*					-	-	-	-	-	-
			3	12	*	*	*	12	140	105	180	40	-	-	-	-		
2,4-dinitrotoluene	BNE	35	1	-	-	-			-	-	-	-		-	-	20	-	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	-	-		
1,2-diphenylhydrazine	BNE	37	1	-	-	-			-	-	-	-		-	-	-	23	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	-	-		
Fluorathene	BNE	39	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					-	-	*	-	-	*
			3	-	-	-	-	-	-	-	-	-	-	-	-	-		
bis(2-chloroisopropyl) ether	BNE	42	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	*	-		
bis(2-chloroethoxy) methane	BNE	43	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	*	-	-		
Isophorone	BNE	54	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					12	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	-	-		
Naphthalene	BNE	55	1	28	23	23			340	70	125	-		285	425	-	-	68
			2	*	35	33	-	-						140	91	-	-	18
			3	27	25	16	*	55	480	305	365	90	92	62	170	-		
N-nitroso diphenyl amine	BNE	62	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	-	41		
bis(2-ethylhexyl) phthalate	BNE	66	1	13	33	22			440	250	300	-		-	-	*	-	*
			2	30	29	17	*	-					*	*	*	*	*	-
			3	43	23	23	14	61	810	-	-	250	*	*	-	*		
Butyl benzyl phthalate	BNE	67	1	-	20	16			-	-	-	-		-	-	*	-	*
			2	21	13	10	*	-					-	*	-	*	*	-
			3	*	14	16	13	27	-	-	-	-	*	10	-	*		
di-n-butyl phthalate	BNE	68	1	*	27	15			-	-	-	-		*	*	-	*	-
			2	*	*	*	*	-					-	*	-	14	*	-
			3	17	11	*	*	22	-	-	-	-	-	-	-	*		
di-n-octyl phthalate	BNE	69	1	-	-	*			-	-	-	-		-	-	-	-	-
			2	-	*	*	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	-	-		

TABLE III-18 (Continued)

ANALYTICAL RESULTS OF PRIORITY POLLUTANTS FOR THE PRETREATMENT SAMPLING PROGRAM - WEEK 2

SEMIVOLATILE ORGANICS (CONCENTRATIONS, ug/l)

				POTW No.2									Effluent to POTW from Refinery No.					
Pollutant	**	Poll No.	Day	Inf.x	Pri.x Eff.	Unoxx Inf.	Unoxx Eff.	Finalx Eff.	xx Centrate	Pri.xx Sludge	Dig.xx Sludge	Filterxx Cake(mg/kg)	13X	21X	45X	43x Direct	43x	16X
diethyl phthalate	BNE	70	1	-	10	*			6	14	6	-		-	-	*	11	-
			2	*	*	*	-	-					38	12	-	-	-	-
			3	*	*	*	-	*	10	15	6	-	-	-	-	-		
dimethylphthalate	BNE	71	1	-	*	-			-	-	-	-		-	-	-	-	*
			2	-	-	*	-	-					-	-	-	-	-	-
			3	-	-	-	-	-	-	-	-	-	-	-	-	-		
benzo(a)anthracene++	BNE	72	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					*	-	*	*	*	-
			3	-	-	-	-	-	-	-	-	-	12	-	-	*		
Chrysene++	BNE	76	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					*	-	*	*	*	-
			3	-	-	-	-	-	-	-	-	-	12	-	-	*		
Acenaphythylene	BNE	77	1	-	-	-			-	-	-	-		-	-	-	-	-
			2	-	-	-	-	-					-	-	-	-	-	-
			3	-	-	*	-	-	-	-	-	-	-	-	-	-		
Anthracene+	BNE	78	1	*	*	*			-	-	-	-		*	81	*	*	*
			2	*	*	*	-	-					36	*	39	-	-	-
			3	*	*	*	-	*	-	-	-	-	29	*	54	*		
Fluorene	BNE	80	1	*	-	-			-	-	-	-		-	-	-	-	-
			2	-	*	*	-	-					14	-	-	-	-	*
			3	*	-	-	-	-	-	-	-	-	*	-	-	-		
Phenanthrene+	BNE	81	1	*	*	*			-	-	-	-		*	81	*	*	*
			2	*	*	*	-	-					36	*	39	-	-	-
			3	*	*	*	-	*	-	-	-	-	29	*	54	*		
Pyrene	BNE	84	1	-	*	-			-	-	-	-		-	-	*	-	-
			2	-	-	-	-	-					*	-	16	*	-	*
			3	-	-	-	-	-	-	-	-	-	*	-	*	-		

NOTE:		
		Of 59 semivolatiles, only 31 were detected
	*	in traces, but below detection limit
	**	AE - Acid Extractable; BNE - Base/Neutral Extractable
	+	Anthracene and Phenanthrene are unresolved
	++	Chrysene and Benzo (a) anthracene are unresolved
	-	Not detected
	x	Samples analyzed by West Coast Technical Services
	xx	Samples analyzed by Pomeroy, Johnston & Bailey

TABLE III-19

Analytical Results of Priority Pollutants for the Pretreatment Sampling Program - Week 2

Pesticides (Concentrations, ug/l)

			POTW No.2									Effluent to POTW from Refinery No.					
Pollutant	Poll No.	xx Day	Inf^{x}	Primary^{x} Eff.	Unox^{x} Inf	Unox^{x} Eff	Final^{x} Eff	xx Centrate	xx Primary Sludge	xx Digested Sludge	xx Filter Cake (mg/kg)	13X	21X	45X	43x Direct	43x	16X
Aldrin	89	1	-	-	-			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	-					-	-	-	-	-	-
		3	3.60	-	0.10	-	-	-	-	-	-	-	1.0	0.29	0.82		
Dieldrin	90	1	-	-	-			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	0.08					-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-	-	-	-	-		
4,4'-DDT	92	1	-	-	-			-	-	-	-		-	-	0.30	-	4.90
		2	-	0.17	-	-	-					0.08	-	0.09	-	-	-
		3	0.11	-	-	-	-	-	-	-	-	0.39	-	-	0.83		
4,4'-DDE	93	1	-	0.09	0.35			-	-	-	-		-	-	-	-	-
		2	0.19	-	0.11	-	-					0.17	-	-	-	-	-
		3	-	-	0.66	-	0.17	-	-	-	-	-	-	-	-		
4,4'-DDD	94	1	0.38	-	-			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	-					-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-	-	-	-	-		
A-endosulfan-Alpha	95	1	-	-	-			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	-					-	-	-	-	-	-
		3	0.12	-	0.52	-	0.22	-	-	-	-	-	-	-	-		
Heptachlor	100	1	0.47	0.10	0.45			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	1.75					-	-	-	-	-	-
		3	0.70	-	-	-	-	-	-	-	-	-	-	-	-		
Heptachlor epoxide	101	1	-	-	-			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	-					-	-	-	-	-	-
		3	-	2.10	-	-	-	-	-	-	-	-	-	-	0.32		
A-BHC-Alpha	102	1	-	-	1.30			-	-	-	-		-	-	0.52	-	-
		2	-	0.24	-	1.5	1.62					-	0.17	0.27	0.36	2.21	0.41
		3	0.88	-	1.20	1.40	0.76	-	-	-	-	0.43	0.08	-	-		
B-BHC-beta	103	1	-	0.16	0.76			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	-					-	-	-	0.32	-	-
		3	-	-	-	-	-	-	-	-	-	-	-	-	-		
R-BHC-Gamma	104	1	-	-	0.27			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	-					-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-	-	-	-	-		
G-BHC-Delta	105	1	1.25	0.45	1.50			-	-	-	-		-	-	-	-	-
		2	-	-	-	-	-					-	-	-	-	-	-
		3	-	-	0.27	-	-	-	-	-	-	-	-	-	-		

NOTE: Of the 25 Pesticides, only 12 were found; however, none of them were confirmed by GCMS

- not detected

x samples analyzed by West Coast Technical Services

xx samples analyzed by Pomeroy, Johnston and Bailey

TABLE III-20

Analytical Results for Priority Pollutants for the Pretreatment Sampling Program - Week 2, Metals (Concentrations, ug/l)

			POTW No. 2									Effluent to POTW from Refinery No.					
Pollutant	Poll. No.	Day	Influent x	Primary Effluent x	Unox Influent x	Unox Effluent x	Final Effluent x	Centrate xx	Primary Sludge xx	Digested Sludge xx	Filter Cake xx(mg/kg)	13 x	21 x	45 x	43x Direct x	43 x	16 x
Antimony	114	1	-	-	-	-	-	58	1000	625	7	-	-	-	-	-	-
		2	33	33	-	-	35	1000	1000	625	13	-	-	-	-	-	-
		3	-	-	-	-	-					-	-	-	-	-	-
Arsenic	115	1	40	-	26	-	29	162	324	285	3	27	-	-	-	60	-
		2	37	-	-	-	-	196	427	297	2	-	-	-	-	67	35
		3	66	-	49	-	-					-	-	-	-	69	34
Beryllium	117	1	-	-	-	-	-	10	4	4	0.04	-	-	-	-	-	-
		2	-	-	-	-	-	2	10	10	0.07	-	-	-	-	-	-
		3	-	-	-	-	-					-	-	-	-	-	-
Cadmium	118	1	28	12	13	-	20	580	2020	1050	16	-	-	-	-	-	-
		2	27	20	14	-	25	1040	1200	1500	9	-	-	-	-	-	-
		3	28	13	77	-	26					-	-	-	-	-	-
Chromium	119	1	520	151	162	45	369	17100	57000	29600	461	1345	747	670	233	72	1644
		2	427	154	177	45	334	27600	39600	42500	249	845	824	646	192	70	2196
		3	573	164	1249	50	456					1133	1254	603	186	64	1800
Copper	120	1	376	141	251	24	390	6900	29000	13300	243	22	14	25	10	57	17
		2	349	153	162	23	311	12300	31000	19200	173	-	17	19	-	47	12
		3	529	176	1019	25	341					-	15	19	-	38	14
Lead	122	1	235	62	58	-	135	4200	18600	10900	214	43	42	33	35	-	39
		2	220	62	50	-	126	7600	18200	15300	247	-	36	-	-	-	-
		3	254	70	277	-	168					-	38	-	-	-	36
Mercury	123	1	0.25	1.69	1.02	2.46	0.49	94	124	232	1.6	0.79	-	0.67	-	-	-
		2	0.37	0.25	0.43	-	-	90	171	147	1.5	0.37	-	0.46	-	-	-
		3	-	0.49	-	-	-					1.08	-	-	-	-	-
Nickel	124	1	399	208	220	206	290	3200	6650	6300	119	-	-	-	-	-	-
		2	265	190	246	236	272	6500	6850	9810	67	-	-	-	-	27	-
		3	304	228	743	310	343					-	-	-	-	-	-
Selenium	125	1	-	-	35	-	29	5	5	6	0.06	101	-	132	-	246	90
		2	33	-	36	-	37	5	5	7	0.06	100	33	158	-	514	199
		3	37	-	66	-	-					110	-	146	-	682	149
Silver	126	1	15	-	-	-	-	70	80	50	0.93	-	-	-	-	-	-
		2	11	-	-	-	11	60	100	90	1	-	-	-	-	-	-
		3	13	-	40	-	10					-	-	-	-	-	-
Thallium	127	1	-	-	-	-	-	20	80	10	0.3	-	-	-	-	-	-
		2	-	-	-	-	-	50	50	50	0.3	-	-	-	-	-	-
		3	-	-	-	-	-					-	-	-	-	-	-
Zinc	128	1	945	274	232	144	820	25600	69000	47000	771	190	153	183	115	57	296
		2	952	375	452	178	810	43400	52600	70000	457	116	173	182	137	49	405
		3	1593	385	2086	178	1027					55	189	174	158	36	398

Notes:
- - Not Detected.
- x Analyzed by EPA Region IV Laboratory.
- xx Analyzed by Pomeroy, Johnston and Bailey.

Centrate, primary sludge, digested sludge and filter cake were not sampled for on day 3.

SECTION IV

SUBCATEGORIZATION

INTRODUCTION

Section 304(b)(2)(B) of the Act requires EPA to take the following factors into account in assessing best available technology: (1) age of equipment and facilities involved; (2) the process employed; (3) the engineering aspects of the application of various types of control technology; (4) process changes; (5) the cost of achieving such effluent reduction; (6) non-water quality environmental impact (including energy requirements), and (7) such other factors as the Administrator deems appropriate. The assessment for best conventional pollutant control technology includes these same factors plus an evaluation of "...the reasonableness of the relationship between the costs of attaining a reduction in effluents and the effluent reduction benefits derived, and the comparison of the cost and level of reduction of such pollutants from the discharge from publicly owned treatment works to the cost and level of reduction of such pollutants from a class or category of industrial sources."

The Agency has considered each of these factors in establishing the proposed effluent limitations. Factors which significantly differentiate groups of industry facilities generally serve as the basis for industry subcategorization. Each subcategory then develops its own technologies representative of BAT, BCT, or BADT.

EPA established effluent limitations and standards (other than pretreatment standards) based on achievable values of three variables: (1) total effluent flow (gallons/day); (2) long-term concentration of each pollutant after BAT, BCT, or BADT treatment; and (3) short-term variations in pollutant concentration after BAT, BCT or BADT treatment which cannot be controlled by good operating practice. It should be noted that short-term variations in flow rate were not considered in establishing effluent limitations. These variations, in contrast to final effluent concentrations, are controllable by good operating practice and design. Flow equalization (collecting effluent in a large tank or pond) is both an available technology (see section VII) and a good operating practice since it minimizes upsets in the treatment system which can cause unnecessary (controllable) variations in final effluent concentration. Flow equalization was a part of BPT model technology, and costs and economic impacts of flow equalization were considered in assessing BPT. Effluent limitations were established by multiplying the achievable values of each variable. In general, an effluent limitation for a specific pollutant parameter is obtained as follows:

$$\text{Limitation} = (\text{Achievable Flow}) \times (\text{Achievable Concentration}) \times (\text{Achievable Variability})$$

The Agency analyzed each factor separately to determine whether it significantly affects the ability of any group of refineries to meet the achievable values of that variable. None of the factors significantly affect the ability of different refineries to meet achievable final effluent concentrations of selected pollutants or achievable concentration variabilities. The only factor which affects achievable effluent flow was factor number (2), "the process employed." Consideration of the additional "cost reasonableness" factor for establishment of BCT technology will be discussed later in this section.

Since process employed was found to be a significant factor in establishing the achievable effluent flow, the Agency considered subcategorizing based on processes employed. Refineries, however, are complex manufacturing facilities. Over one hundred distinct processes are used in the petroleum refining point source category. Moreover, sizes (throughputs) of the processes were found to affect effluent flow. It is not practical to group refineries by both process and size of process because each refinery would be a distinct subcategory.

The Agency then considered the possibility of developing a mathematical model which would correlate achievable effluent flow with a relatively small number of process variables. Such a mathematical model (flow model) would insure that the "process employed" factor would be considered on an industry-wide basis. Industry-wide effluent limitations could be developed without establishment of subcategories containing only a very few facilities (possibly one per subcategory).

Current BPT limitations are based on the approach of establishing a flow model to account for the factor "process employed" (3). Five flow models were established to determine achievable flow and each model was applicable to a group of petroleum refineries (topping, cracking, petrochemical, lube and integrated refineries). Thus, the industry was divided into five subcategories. The flow model used as a basis for BPT determined achievable flow based on two variables (one related to the size of the plant and one related to the complexity of the plant).

For the current flow modeling effort, the Agency used the effluent flows and the process characteristics reported in the "1977 Survey". The Agency reevaluated the BPT flow models based on the more current data from the 1977 survey and found the BPT flow model to be very poor in predicting the effluent flows which had been achieved by the industry in 1976. Consequently, other flow models were explored.

FLOW MODELING EFFORT

Data Screening and Evaluation

The data from the 1977 survey were reviewed and questionable information was verified or corrected by subsequent telephone contacts and additional mailings. The follow up mailings focused primarily on the interpretation of process values and wastewater flows ("Supplemental Flow Questions and Verification Report"). The flow modeling procedure uses only these supplemental flow values in its analysis. Figure IV-1 a plot of the wastewater flow values versus the size of refinery, depicts the flow figures used in the analysis.

Regression Analysis

EPA has developed models of refinery wastewater flows based on a statistical analysis of the verified 1977 EPA Petroleum Refining Industry Survey data. This analysis was performed primarily through the use of multiple linear regression techniques. With this approach, an equation of the form

$$Y = A_o + \sum_{i=1}^{n} A_i X_i \qquad \text{Equation (1)}$$

(Note: $\sum_{i=1}^{n}$ means the summation from 1 to n.

For example, if 3 variables were used (n=3)

$$Y = A_o + A_1 X_1 + A_2 X_2 + A_3 X_3)$$

is used to explain the relationship between a dependent variable (wastewater flow in this case) and a set of independent variables (such as process characteristics). Regression analysis assumes that the underlying relationships among the variables are linear as expressed in the above equation.

The flow modeling analysis begins with the hypothesis that the petroleum refining industry effluent flow data can be modeled by the relationship

$$Y = A_o + \sum_{i=1}^{n} A_i X_i + E_i \quad \text{Equation (2)}$$

where,

Y = magnitude of the effluent flow

A_o, A_i = constants to be determined by the regression analysis

X_i = characteristics of petroleum refineries and the petroleum refining industry

E_i = random variable with a mean value of zero.

The independent variables are not restricted to representing a single, unique physical characteristic; their functions take any form. For an industry-wide relationship, the E_i term in the above model assumes its expected value of zero.

The goal of the modeling procedure is to explain the variability of wastewater flow among refineries as thoroughly as possible. Each physical characteristic (variable) included in the model (i.e., the unit processes within a refinery) account for some portion of the total flow. Any flow not attributable to the specific variables of the model can be attributed to some process represented by the E_i variable. The larger the degree by which the model represents the real world situation, the smaller will be the variability of the random variable and the greater the accuracy of the model. If the magnitude of the wastewater flow were entirely explained by physical characteristics, the model would need no random component. Because an infinite amount of information is not available, however, the model assumes only that all unknown factors will average to a zero value over the entire industry. A non-zero expected value of E_i is indicative of a biased model and a failure of the modeling procedure.

BPT Model

Current BPT limitations for the refining industry are based on a linear model of industry effluent flows. This BPT model was developed using process and flow data from the 1972 EPA-API industry survey and appears as:

$$Y = A_o + A_1X_1 + A_2X_2 \qquad \text{Equation (3)}$$

With components,

$Y = \text{Log}_{10}$ (total flow/capacity)

A_o = Subcategory dependent constant

A_1, A_2 = Regression coefficient constants (1.51 and 0.0738, respectively)

X_1 = Refinery throughput

X_2 = Sum of weighting factors for a particular refinery.

For the development of BPT regulations, the equation was mathematically transformed from the standard slope-intercept representation shown above to a form denoting deviation from a subcategory average value. The refinery process weighting factors are the normalized coefficients of the regression model:

$$Z = A_o + \sum_{i=1}^{n} A_i X_i \qquad \text{Equation (4)}$$

where

Z = effluent flow

A_o = regression constant

A_i = regression constant (weighting factor) corresponding to the ith petroleum refining process.

X_i = throughput for process i.

BPT subcategorization was designed to give overall minimum variance to the system; i.e., variance within each subcategory was minimized and the differences between the subcategories were maximized.

Current Flow Model Development

The development of the BAT effluent flow model differs in several basic modeling assumptions from that of the BPT modeling effort. The primary difference is the wastewater quantity predicted by the two models.

The BPT flow model identifies the dependent variable (flow) in terms of gallons of effluent discharged per barrel of raw input feedstock, whereas the newly developed BAT model predicts only the gallons of wastewater generated (not necessarily discharged. The total wastewater generated from each refinery is the sum of the wastwater associated with each in-plant process. The flow model does not incorporate information on the reuse of wastewater.

Attempts were made during the modeling effort to develop a relationship between the gallons of wastewater generated per barrel unit of feedstock input and the process capacities. Such endeavors were unsuccessful. The Agency could develop no reasonable models by which to identify a gallon per barrel wastewater flow.

From a theoretical viewpoint, the gallons per barrel figure is a transformation of the total flow multiplied by the size of the primary process. Realistically, however, although some water is generated at this stage of the refining chain, the refinery effluent flow appears more dependent on the configuration of the processes down stream from the primary process.

Regression analyses using a gallons per barrel dependent variable produced models which at best could explain only half the variability of the effluent flow data.

Another major difference between the BPT and the BAT flow models is in their forms. The BPT model is an exponential multiplicative model in its two terms of size and complexity. The BAT model is linear and additive in its terms.

The decision not to use an exponential form for the present model was made after a careful study of the available facts. It was closely related to the more general decision not to perform any transformation to the data at all. Any transformation of data reduces the effect of some of the data points. Although transformation at first appear beneficial for this set of data, such an action tend to deemphasize the larger size refineries, even though it is the larger size refineries for which so few data points exist. Compromising theoretical statistical purity to insured that the effects of all refinery sites were equitably considered.

The endeavors to develop a viable flow model progressed through several distinct stages, each one building on previous efforts. The statistical measure of "goodness of fit" also increased at each stage.

Initially, the model assumed that effluent flows could be determined based on all the known sources of wastewater in refineries and all the known descriptive characteristics of refineries. This assumption proved to be false.

Factors which impact wastewater generation is so numerous that data to quantitatively describe their affect would be impossible to gather or to analyze. The best that can be hoped in flow modeling is that a reasonable approximation of what occurs in a refinery can be formulated.

The first flow model attempted to identify individual refinery characteristics related to wastewater production. Because nearly every refinery characteristic is correlated to some degree with the magnitude of wastewater produced, cause and effect relations were extremely difficult to separate from random relations. Moreover, a given characteristic had different effects on wastewater generation depending on the particular refineries under study.

The result of this stage of the model development process was the realization that many refinery characteristics do not correlate well with flow. The analysis established that only refinery process characteristics should be included in the model. Because process wastewaters account for only 70 percent of the total effluent generated, the Agency had to accept the fact that a model based solely on process information could not be 100 percent accurate. Remaining variations would have to be included in the error term (E_i), and error terms from the resulting model would have to be analyzed for equity among refineries.

The next model used only single ungrouped processes as the modeling factors. A variety of these models were developed with differing degrees of success. Examples of these may be found in the earlier draft reports (125). The lack of real life physical correspondence was the major drawback to these forms. One characteristic of these models was that almost any combination of processes eventually produced regression models with R^2 values in the neighborhood of .70. R^2 values (also known as correlation coefficients) measure the degree to which the model explains the variation in the dependent variable (flow).

After considerable experimentation with ungrouped processes, the Agency next tried models based on processes grouped by distinguishing characteristics.

The final flow model is a compromise among perfect statistical, regulatory, and physical factors. This model contains the same factors as the original BPT flow model, except for the size factor and the coking effect. The general form of the model is as follows:

FLOW = industry average flow

+ Asphalt effect (Equation 5)
+ Crude effect
+ Cracking effect
+ Lube effect

The regression analysis from which this model is derived indicated an R^2 of .749 with an overall F-distribution test statistic of 166. A total of 227 plants possessed valid data for the analysis. The independent model variable statistics are as follows:

	Standard Error	F	Regression Coef.
Asphalt	.02462	3.862	.04838
Crude	.00112	13.661	.00415
Cracking	.00664	48.287	.04617
Lube	.01073	20.052	.04806

The proposed form of the model for use in guidelines administration is:

Effluent Flow Model

$$\begin{aligned} \text{FLOW} = .568 &+ .048A \qquad \text{(Equation 6)} \\ &+ .004\,(C-59.2) \\ &+ .046\,(K-7.2) \\ &+ .048L \end{aligned}$$

The simplified form of this equation is as follows:

$$\text{FLOW} = 0.004C + 0.046K + 0.048\,(A + L).$$

Constants are median values.
Flow is in units of million gallons per day.
A,C,K,L are in units of thousands of barrels per day throughput
Constants are in units of million gallons per thousand barrels per day.

Where,

A = sum of asphalt processes
- Asphalt Production
- Asphalt Oxidizer
- Asphalt Emulsifying

K = sum of cracking processes
- Hydrocracking
- Visbreaking
- Thermal Cracking
- Fluid Catalytic Cracking
- Moving Bed Catalytic Cracking

C = sum of crude processes
- Atmospheric Crude Distillation
- Crude Desalting
- Vacuum Crude Distillation

L = sum of lube processes
- Hydrofining, Hydrofinishing, Lube Hydrofining
- White Oil Manufacture
- Propane Dewaxing, Propane Deasphalting, Propane Fractioning, Propane Deresining
- Duo Sol, Solvent Treating, Solvent Extraction, Duotreating, Solvent Dewaxing, Solvent Deasphalt
- Lube Vac Twr, Oil Fractionation, Batch Still (Naphtha Strip), Bright Stock Treating

Centrifuge and Chilling
MEK Dewaxing, Ketone Dewaxing, MEK-Toluene Dewaxing
Deoiling (wax)
Naphthenic Lubes Production
SO_2 Extraction
Wax Pressing
Wax Plant (with Neutral Separation)
Furfural Extracting
Clay Contacting - Percolation
Wax Sweating
Acid Treat
Phenol Extraction
Lube and Fuel Additives
Sulfonate Plant
MIBK
Wax Slabbing
Rust Preventives
Petrolatum Oxidation
Grease Mfg. V. Allied Products
Misc. Blending and Packaging

Use of the Flow Model

The flow model presented above (equation 6) predicts current industry flow on a refinery by refinery basis. The model is used for regulatory purposes as representing the current wastewater generation flow rate of the industry. This is analogous to using analytical data (from section IV) as representing current concentrations of various pollutants in final effluent discharges. If additional end-of-pipe treatment (such as activated carbon) is applied as BAT, then lower final effluent concentrations would be used in establishing BAT limitations. Similarly, if flow reduction is established as BAT technology (see CONTROL AND TREATMENT TECHNOLOGY section VII), then correspondingly lower flows than those predicted by the flow model would be used in establishing BAT limitations.

The flow model does not, and is not intended to, exactly predict current flows from each refinery. Some of these variations are purely statistical variations. Much of the variation, however, is explained by the fact that refineries discharging less effluent than the model predicts are employing flow reduction technology (see CONTROL AND TREATMENT TECHNOLOGY Section VI) which is not employed by refineries discharging more effluent than the model predicts. In considering technology options for BAT and BCT, the Agency calculated compliance costs on a plant-by-plant basis. For technology options which included flow reduction, compliance costs were calculated for reducing flow from actual flow (1977) to the flow required by that option. Economic impacts also were assessed on a plant-by-plant basis.

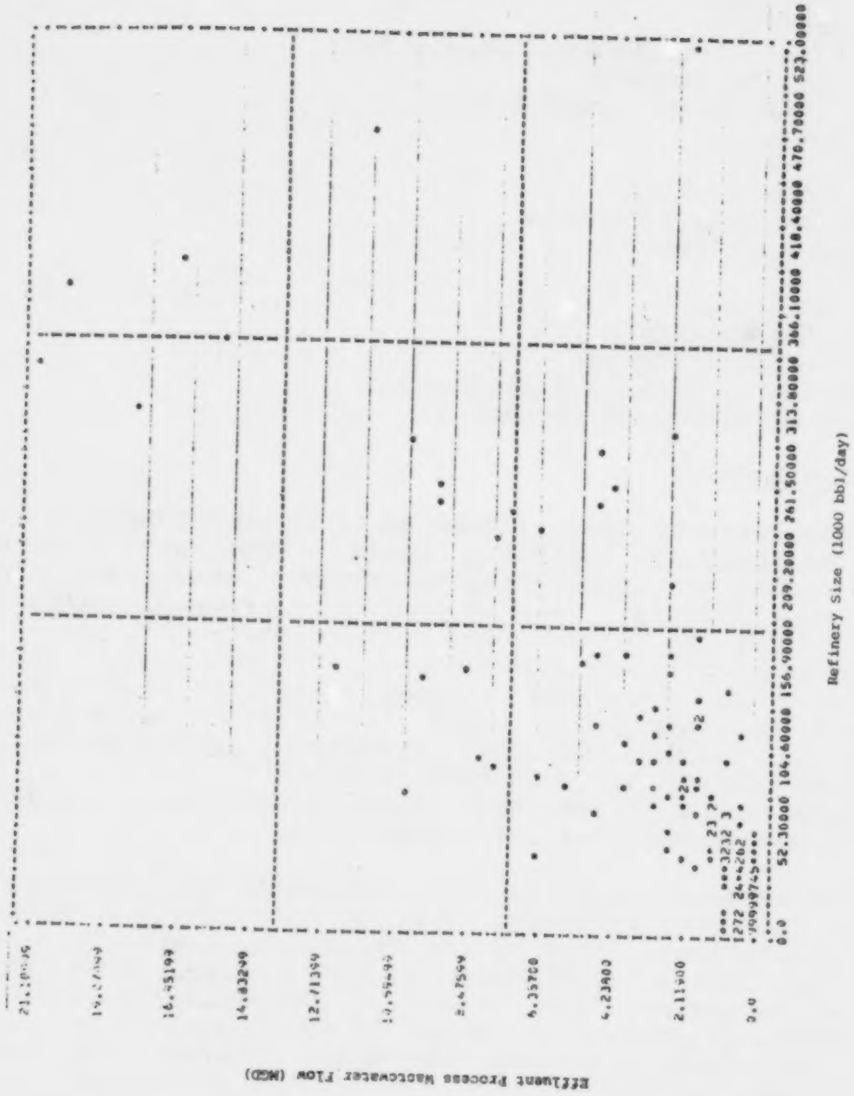


FIGURE IV-1
Process Wastewater Flow Versus Refinery Size

SECTION V

SELECTION OF POLLUTANT PARAMETERS

INTRODUCTION

EPA has studied petroleum refinery wastewaters to determine the potential presence of toxic, conventional, and non-conventional pollutants. The result of the study is provided in Section III of this document.

The Settlement Agreement in Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified March 9, 1979, requires that effluent limitations and standards be established for each of the sixty-five (65) toxic pollutants or classes of pollutants (Table II-1) unless the Administrator determines that it should be excluded from rulemaking under Paragraph 8 of the subject Agreement.

POLLUTANTS FROM PETROLEUM REFINING INDUSTRY

EPA has conducted an extensive sampling and analytical program to determine the presence of toxic, conventional and non-conventional pollutants in petroleum refinery wastewaters. The program included the sampling of seventeen (17) direct dischargers, six (6) indirect dischargers, and two (2) POTWs. The American Petroleum Institute has split samples with EPA for the above program at nine (9) direct discharge refineries, three (3) indirect discharge refineries and one (1) POTW sites. The analytical results from the EPA and API laboratories are presented in Section III and Appendix 3.

The conventional and non-conventional pollutants analyzed were found in all the effluent streams. The toxic pollutants were detected at less frequent intervals. Table V-1 lists the seventy-six (76) toxic pollutants that were not found in the treated effluents from direct dischargers. Of the remaining forty-seven pollutants, seven were found in the effluent of only one refinery and were uniquely related to that refinery (not found in the raw wastewaters from any other plants). These seven pollutants and the remaining pollutants are listed in Table V-2 and V-3. A pollutant is considered detected if it occurs at a concentration higher than its concentration in the plant's source water.

SELECTION OF REGULATED POLLUTANTS FOR DIRECT DISCHARGERS

The pollutants insufficiently controlled by BPT include phenol, chromium (hexavalent and trivalent), TSS, BOD and oil and grease. These pollutants were selected on the basis of their environmental significance and/or the availability of treatment technology. Reasons for not further regulating the other pollutants are provided below.

Paragraph 8 of the Settlement Agreement (as modified) provides for excluding toxic pollutants from regulations and standards. Paragraph 8(a)(iii) of the Revised Settlement Agreement allows the Administrator to exclude from regulation toxic pollutants not detectable by Section 304(h) analytical methods or state of the art methods. Pollutants listed in Table V-1 are, therefore, excluded from regulation. Paragraph 8(a)(iii) also allows the Administrator to exclude from regulation toxic pollutants detected in the effluent from a small number of sources and uniquely related to those sources. The seven pollutants in Table V-2 satisfy this criteria. Pollutants which were found in the treated effluent at only one refinery but which were detected in the untreated effluent of a number of facilities are not considered uniquely related to one plant.

Paragraph 8(a)(iii) also excludes from regulation toxic pollutants which were detected but for which no known treatment technology exists to reduce their discharge, or which are effectively controlled by the technology upon which other effluent limitations are based. The Agency believes that the technology upon which the proposed BAT effluent limitations for phenol (4AAP) and chromium are based will effectively control the organic and metallic toxic pollutants in Table V-3 with the exception of cyanide. Cyanide with final effluent concentration as high as 170 ppb is discharged by the petroleum refining industry, but EPA is not aware of any end-of-pipe technology which will reduce cyanide discharges beyond its current level. The Agency plans to continue study of this problem to determine whether cyanide discharges can be reduced by in-plant control.

SELECTION OF REGULATED POLLUTANTS FOR PRETREATMENT STANDARDS

Section 307(b) of the Clean Water Act requires EPA to promulgate pretreatment standards for both existing and new sources which discharge their wastes into publicly owned treatment works (POTW). These pretreatment standards are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. In addition, the Clean Water Act of 1977 adds a new dimension to these standards by requiring pretreatment of pollutants, such as metals, that limit POTW sludge management alternatives.

EPA has sampled six indirect discharge plants and two POTWs API split samples with EPA at half of these facilities. Toxic pollutants found and not found in the effluents from these refineries and POTW's are listed in Table V-4 and V-5, respectively.

Ammonia and oil and grease at concentrations exceeding 100 mg/l can interfere with the operation of POTW's. Chromium from refineries will accumulate in POTW sludges and will limit the sludge management alternatives of the POTW.

Paragraphs 8(a)(i) and 8(a)(iii) of the Revised Settlement Agreement allow the administrator to exclude pollutants from regulations under pretreatment standards. The pollutants listed in Table V-5 are excluded from pretreatment regulations because they were not found in the refineries' discharges to the POTW's. Toxic pollutants other than chromium are excluded from regulation because they are controlled adequately by existing PSES if the refinery discharges into a secondary POTW. Refineries which route their wastes to primary POTWs require additional control. Table V-6 lists those priority pollutants which pass through primary POTWs.

TABLE V-1

Toxic Pollutants Not Detected In Treated Effluents (Direct Discharge)

1. Organics

acrolein
acrylonitrile
chlorobenzene
1,1,1-trichloroethane
1,1-dichloroethane
1,1,2-trichloroethane
chloroethane
2-chloroethylvinyl ether
chloroform
methyl chloride
methyl bromide
bromoform
trichlorofluoromethane
dichlorodifluoromethane
chlorodibromomethane
vinyl chloride
acenaphthene
benzidine
1,2,4-trichlorobenzene
hexachlorobenzene
hexachloroethane
bis(chloromethyl) ether
bis(2-chloroethyl) ether
2-chloronaphthalene
2,4,6-trichlorophenol
2-chlorophenol
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
3,3'-dichlorobenzidine
2,4-dinitrotoluene
2,6-dinitrotoluene
1,2-diphenylhydrazine
4-chlorophynyl phenyl ether
4-bromophenyl phenyl ether
bis(2-chloroisopropyl) ether
bis(2-chloroethoxy) methane
hexachlorobutadiene
hexachlorocyclopentadiene
isophorone
nitrobenzene
2-nitrophenol
2,4-dinitrophenol
4,6-dinitro-o-cresol
N-nitrosodimethylamine
N-nitrosodiphenylamine
N-nitrosodi-n-propylamine
pentachlorophenol
butyl benzyl phthalate
di-n-octyl phthalate
3,4-benzofluoranthene
benzo(k)fluoranthane
acenaphthylene
dibenzo(a,h)anthracene
ideno(1,2,3-cd)pyrene
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

2. Pesticides

aldrin
dieldrin
chlordane
4,4'DDT
4,4'-DDE
4,4'-DDD
a-endosulfan-Alpha
b-endosulfan-Beta
endosulfan sulfate
endrin
endrin aldehyde
heptachlor
heptachlor epoxide
a-BHC-Alpha
b-BHC-Beta
r-BHC-Gamma
g-BHC-Delta
PCB-1242
PCB-1254

3. Metals

None

4. Others (Asbestos, 4AAP Phenol)

asbestos (fibrous)

TABLE V-2

Toxic Pollutants Found in Only One Refinery Effluent (at concentrations higher than those found in the intake water) and which are Uniquely Related to the Refinery at Which it was Detected (Direct Discharge)

1. Organics

Carbon tetrachloride
1,1-dichloroethylene
1,2-dichloropropane
1,2-dichloropropylene
2,4-dichlorophenol
di-n-butyl phthalate
dimethyl phthalate

2. Pesticides

None

3. Metals

None

4. Others (Asbestos, 4AAP Phenol)

None

TABLE V-3

Toxic Pollutants Detected in Treated Effluents of More Than One Pefinery or Detected in the Treated Effluents of One Refinery but Not Uniquely Related to the Refinery at Which it Was Detected (Direct Discharge)

1. Organics

Benzene
1,2-dichloroethane
1,1,2,2-tetrachloroethane
parachlorometa cresol
1,2-trans-dichloroethylene
2,4-dimethylphenol
ethylbenzene
fluoranthene
methylene chloride
dichlorobromomethane
naphthalene
4-nitrophenol
phenol
bis(2-ehtylhexyl) phthalate
diethyl phthalate
benzo(a)anthracene
benzo(a)pyrene
chrysene
anthracene
benzo(ghi)perylene
fluorene
phenanthrene
pyrene
tetrachloroethylene
toluene
trichloroethylene

2. Pesticides

None

3. Metals

antimony (total)
arsenic (total)
chromium (total)
beryllium (total)
cadmium (total)
copper (total)
cyanide (total)
lead (total)
mercury (total)
nickel (total)
selenium (total)
silver
thallium (total)
zinc (total)

4. Others (Asbestos, 4AAP Phenol)

None

TABLE V-4

Toxic Pollutants Detected in Discharges to POTWs (Indirect Discharge)

1. Organics

benzene
chlorobenzene
1,2-dichloroethane
1,1,1-trichloroethane
chloroform
ethylbenzene
methylene chloride
tetrachloroethylene
toluene
acenaphthene
2,4-dimethylphenol
2,4-dinitrotoluene
1,2-diphenylhydrazine
isophorone
naphthalene
N-nitrosodiphenylamine
pentachlorophenol
phenol
butyl benzyl phthalate
di-n-butyl phthalate
di-n-octyl phthalate
diethyl phthalate
benzo(a)anthracene
chrysene
anthracene
fluorene
phenanthrene
pyrene

2. Pesticides

aldrin
4,4'-DDT
4,4'DDE
heptachlor epoxide
a-BHC-Alpha
b-BHC-Beta

3. Metals

arsenic (total)
chromium (total)
copper (total)
lead (total)
mercury (total)
nickel (total)
selenium (total)
zinc (total)

4. Others (Asbestos, 4AAP Phenol)

Not analyzed

TABLE V-5

Toxic Pollutants Not Detected in Discharges to POTW (Indirect Discharge)

1. Organics

acrolein
acrylonitrile
carbon tetrachloride
1,1-dichloroethane
1,1,2-trichloroethane
1,1,2,2-tetrachloroethane
chloroethane
2-chloroethylvinyl ether
1,1-dichloroethylene
1,2-trans-dichloroethylene
1,2-dichloropropane
1,2-dichloropropylene
methyl chloride
methyl bromide
bromoform
dichlorobromomethane
trichlorofluoromethane
dichlorodifluoromethane
chlorodibromomethane
trichloroethylene
vinyl chloride
benzidine
1,2,4,-trichlorobenzene
hexachlorobenzene
hexachloroethane
bis(chloromethyl) ether
bis(2-chloroethyl) ether
2-chloronaphthalene
2,4,6-trichlorophenol
parachlorometa cresol
2-chlorophenol
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
3,3'-dichlorobenzidine
2,4-dichlorophenol
2,6-dinitrotoluene
fluoranthene
4-chlorophenyl phenyl ether
4-bromophenyl phenyl ether
bis(2-chloroisopropyl) ether
bis(2-chloroethoxy) methane
hexachlorobutadiene
hexachlorocyclopentadiene
nitrobenzene
2-nitrophenol
4-nitrophenol
2,4-dinitrophenol
4,6-dinitro-o-cresol
N-nitrosodimethylamine
N-nitrosodi-n-propylamine
bis(2-ethylhexyl) phthalate
dimethyl phthalate
benzo(a)pyrene
3,4-benzofluoranthene
benzo(k)fluoranthene
acenaphthylene
benzo(ghi)perylene
dibenzo(a,h)anthracene
ideno(1,2,3-cd)pyrene
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

2. Pesticides

dieldrin
chlordane
4,4'-DDD
a-endosulfan-Alpha
b-endosulfan-Beta
endosulfan sulfate
g-BHC-Delta
PCB-1242
PCB-1254
PCB-1221
PCB-1232
PCB-1248

endrin
endrin aldehyde
heptachlor
r-BHC-Gamma
PCB-1260
PCB-1016
toxaphene

3. Metals

antimony (total)
beryllium (total)
cadmium (total)
silver (total)
thallium (total)
cyanide (total)

4. Others (Asbestos, 4 AAP Phenol)

Not analyzed

TABLE V-6

Toxic Pollutants Found to Pass Through POTW with Only Primary Treatment (Indirect Discharge)

1. Organics

benzene
1,2-dichloroethane
1,1,1-trichloroethane
chloroform
ethylbenzene
methylene chloride
tetrachloroethylene
toluene
2,4-dimethylphenol
naphthalene
phenol
butyl benzyl phthalate
di-n-butyl phthalate
di-n-octyl phthalate
diethyl phthalate

2. Pesticides

4,4'-DDT
4,4'-DDE
a-BHC-Alpha
b-BHC-Beta

3. Metals

arsenic (total)
chromium (total)
copper (total)
lead (total)
mercury (total)
nickel (total)
selenium (total)
zinc (total)

4. Others (Asbestos, 4AAP Phenol)
Not analyzed

SECTION VI

CONTROL AND TREATMENT TECHNOLOGY

INTRODUCTION

This section addresses the control and treatment technologies that apply to petroleum refining wastewaters. Petroleum refinery wastewaters vary in quality and quantity. Nevertheless, they all were readily In identifying available treatment technologies, the Agency assumed that each refinery had or would install treatment equipment to comply with limitations based on best practicable control technology currently available (BPT) (3). The treatment technologies described below are those which can reduce further the discharge of toxic pollutants to navigable waters. They are divided into two broad classes -- in-plant source control and end-of-pipe treatment.

In-Plant Source Control

In-plant source control affords two major benefits afforded (1) the overall reduction of pollutant load that must be treated by an end-of-pipe system; and (2) the reduction or elimination of a particular pollutant parameter before dilution in the main wastewater stream.

In developing an in-plant control schemes the source of each particular pollutant must be identified, evaluated as to whether it can be eliminated, or reduced. This can be accomplished by sampling the wastewater at various points within the refinery sewer, beginning at the end-of-pipe treatment system, and ending at the process units. This procedure produces a profile of the refinery sewer showing the origin and flow path of the pollutant in question.

Once the source of the particular pollutant is identified, the next step determines if the pollutant: (a) can be removed with an in-plant treatment system; (b) can be eliminated by substitution, if it is a purchased item; or (c) can be reduced by the recycle or reuse of the particular wastewater stream. Discussions of each of these in-plant treatment options, as they relate to a particular waste stream or pollutant parameter, are presented below.

In-Plant Treatment Options

All in-plant treatment options require the segregation of the process waste streams under consideration. If there are multiple sources of the particular pollutant or pollutants, they all require segregation from the main wastewater sewer. However, similar sources can be combined for treatment in one system. Sour waters illustrate a type of wastewater that is produced at various locations within a refinery complex, but that can be treated as one combined wastewater stream.

Sour waters and cooling tower blowdown are the two waste streams for which in-plant treatments are being practiced or are available.

Sour Waters.

Sour waters generally result from water brought into direct contact with a hydrocarbon stream. This occurs when steam is used as a stripping or mixing medium, or when water is used as a washing medium, as in the crude desalting unit. Sour waters contain sulfides, ammonia, and phenols.

The most common in-plant treatment schemes for sour waters involve sour water stripping, sour water oxidizing, or combinations of the two. Table VI-1 summarizes the extent of this technology in the refining industry. The operation of sour water strippers and sour water oxidizers has been discussed at great length in numerous technical publications (3, 6, 18, 20, 24, 28, 48); there is no need to discuss these treatment units in detail. However, it should be emphasized that these systems can greatly reduce sulfides and ammonia levels, and also can afford some removal of phenols (24). A sour water stripping study was undertaken in 1972 by the American Petroleum Institute (24). The results of this survey showed that 17 out of 31 refluxed sour water strippers and 12 out of 24 non-refluxed sour water strippers achieved greater than 99% removal of sulfides. An additional nine refluxed and three non-refluxed units achieved greater than 99% removal of sulfides and greater than 95% removal of ammonia. The data thus suggests that refluxed columns afford better overall removals of both pollutants. It should be noted that of five two-stage units reported, only one unit achieved high removals of both parameters. Six out of seven strippers operating with flue or fuel gases removed over 99% of the sulfides. However, none of these units achieved high ammonia removals.

The average effluent of all refluxed, non-refluxed, and flue gas units which achieved greater than 99% sulfide removal was 6.7 mg/l of sulfide. The average effluent from all units which achieved greater than 95% ammonia removal was 62.5 mg/l of ammonia. These averages are based upon a wide range of influent and effluent values.

Existing sour water stripper performance can be improved by (a) increasing the number of trays, (b) increasing the steam rate; (c) increasing tower height; and (d) adding a second column in series (107). All of these methods are available already to the refining industry.

Biological treatment to remove total phenols is also a demonstrated technology in this industry (48). Biological treatment of stripped sour waters may prove cost-effectiveness for the removal of any biodegradable organic priority pollutants that may originate in this waste stream.

Phenol removal from the sour water waste stream can also be accomplished by the addition of oxidizing agents, such as ozone (51), hydrogen peroxide (11), chlorine, chlorine dioxide, and potassium permanganate (113).

A recent research project has demonstrated that activated carbon will also removes phenolic compounds. The experiment showed that activated carbon has a high affinity for phenolic compounds, so that relatively short detention times are required. Activated carbon treatment in sour water streams also may remove other organic priority pollutants that may be present. Refinery No. 237 uses activated carbon for treatment of the sour water waste stream, and the Agency is investigating this particular system further.

Cooling Tower Blowdown.

Removal of metals (such as chromium and zinc) and phosphate can be achieved by precipitation and clarification at a relatively high pH (8 - 10). Hexavalent chromium, however, must be first reduced to the trivalent state before it can be precipitated and removed by clarification. This usually is accomplished by the addition of sulfur dioxide, ferrous sulfate, or sodium bisulfite. The pH of the wastewater then rises with the addition of lime or caustic (lime is preferred if phosphates are to be precipitated); clarification of the wastewater stream follows. Flocculants and flocculant aids, such as ferric chloride, alum, and polymers, can be added to increase removal efficiencies.

Japan's Mitsubishi Petrochemical Company has reported a new treatment technique for the removal of heavy metal ions (126). The system involves electrolytic coagulation in which electrical currents causes an iron electrode to dissolve. The iron combines with heavy metals and added hydroxide ion to form a sludge that can be precipitated rapidly from solution. Magnets aid the settling process. Mitsubishi reports that the new treatment system can reduce Cr^{+6} concentration to less than 0.05 ppm in 2900 gallons of metal plating wastewater. This system could apply to the treatment of cooling tower blowdown streams at petroleum refineries.

None of the 259 refineries in the 1977 survey indicated in-plant treatment schemes designed specifically for chromium removal; treatment equipment vendors, however, indicate that several refineries have installed such treatment.

Chemical Substitutions

Chemicals are added to cooling tower recirculating water and boiler water to reduce corrosion, scaling, and biological growth. These chemicals usually include chromium, zinc, phosphates, and free chlorine, as well as other potential pollutants.

Using organic chemicals to replace for zinc and chromium solutions is also a viable alternative (53,54). Molybdates are also a practical alternative (55). (Molybdates are compounds containing the anion MoO_4^{2-}.)

Wastewater Reduction and Reuse

Reduction. Reduction in water usage sometimes may be more cost effective in reducing the quantity of wastewater discharge than water reuse or recycle. Good housekeeping is one inexpensive method of reducing wastewater production. It may include: (a) shutting down pump gland cooling water lines on pumps that are out of service; (b) shutting down wash down hoses that are not in use; (c) eliminating leaks; (d) using dry cleaning methods; and (e) using vacuum trucks to clean up oil spills. Numerous other housekeeping procedures commonly are practiced throughout the industry.

Many new and modified refineries incoporate reduced water use and pollutant loading into their design. Some of these modifications include:

1. Substitution of improved catalysts that require less regeneration.

2. Replacement of barometric condensers with surface condensers or air fan coolers.

3. Replacement of surface condensers with air fan coolers.

4. Newer hydrocracking and hydrotreating processes which produce lower wastewater loadings than the older processes.

5. Increased use of improved drying, sweetening, and finishing procedures to minimize spent caustics and acids, water washes, and filter solids requiring disposal.

6. Recycle of wastewwater at the process units, to reduce the amount of wastewater leaving the process area.

A major process change that can reduce wastewater production is the substitution of air cooling devices for water cooling systems. Many refineries have installed air cooling systems with their new process installations, thereby reducing the additional wastewater production associated with increased refinery complexity.

Of the 78 refineries for which data are available for comparison between 1972 and 1976, the percentage use of air cooling systems has increased at 39 refineries, has decreased at 26 refineries and has rendered the same at 13 refineries. Increasing use of air cooling systems can reduce the quantity of cooling tower blowdown discharges that require treatment.

Another method of wastewater reduction is the elimination of cooling water from general purpose pumps (117). In certain instances the elimination of water can increase machinery reliability, reduce capital expenditures for piping and water treatment facilities, and save operating costs guidelines are available for implementation of a well-planned, step-by-step program of deleting cooling water from pumps and drivers. These procedures have been successfully implemented on a full-scale basis (117).

Reuse. Many of the streams, such as treated sour waters, cooling tower blowdowns, and utility blowdowns, are suitable for use as wash waters and fire system water. However, reuse of wastewaters for these purposes requires investigation on a plant-by-plant basis to determine the technical and economic feasibility.

Wastewaters emanating from end-of-pipe BPT facilities are generally of such quality that reuse can be quite attractive. Uses for treated refinery wastewaters include make-up to cooling towers, pump gland cooling systems, wash-down waters, and fire water systems.

A number of articles in recent years have described actual reuse practices at one refinery (41, 57, 58). This plant reuses most of its treated wastewater as make-up to the cooling tower and fire water systems. In practice, the cooling towers act as biological treatment units, and remove in excess of 99% of the phenols present (41). The refinery reuses approximately 4.5 million gallons of process wastewater per day in their cooling towers; about 2.2 million gallons of cooling tower blowdown per day are sand filtered and discharged to the receiving stream. The difference, in excess of 2 million gallons per day, is evaporated in the cooling towers or in an impounding basin (58). Wastewater reuse began at this refinery in 1954. Years of operating experience have confirmed that reuse water is a satisfactory make-up supply to cooling towers and does not require special water conditioning or treatment. Continued monitoring has confirmed that the system has no problems of corrosion, heat transfer, or cooling tower wood deterioration. The refinery has concluded that cooling tower reuse is an economically sound practice, paying significant dividends in terms of both pollution abatement and water conservation (57).

Two recent articles discussed the reduction of wastewater generation by the use of: (a) side stream softening to reduce cooling tower blowdown flow; and (b) reuse of properly treated wastewater as make-up to a cooling tower system.

Reed, et al. report that side stream softening can greatly reduce cooling tower blowdown. They conclude that by-pass lime softening appears to be a realistic technique applicable to both new and existing cooling tower systems. Cooling water systems in high dissolved solids applications can be expected to be adequately protected through the use of corrosion inhibitors. The authors present a method for designing for zero blowdown applications and for predicting steady state conditions. A pilot cooling tower was operated with a recirculating water chemistry designed to simulate the ultra-high TDS levels, representative of conditions expected for zero blowdown systems. Low corrosion rates on mild steel and copper alloy specimens were reported after application of a proprietary synergistic chromate corrosion inhibitor. These low corrosion rates were especially pertient to the application of zero blowdown systems at existing installations having considerable amount of mild steel and copper plumbing and process equipment (127).

Finelt and Crump (128) report that refiners faced with increasing fresh water costs may direct their water management policies toward the recirculation of treated water. Properly treated wastewater can be recycled as make-up to the cooling tower system. At new refineries, it is possible that the recycle system could be justified economically over a non-recycle system. There are a number of factors to be considered, most notably the cost of fresh water, determing the least costly system. At existing well-operated facilities, only at very high fresh water costs can the recycle system prove to be less costly than a non-recycle system. However, application of recycle technology can reduce effluent discharge by up to ninety percent and possibly help to establish "zero discharge" facilities.

The use of sour waters as make-up to the desalter is a proven technology in this industry. This practice does remove some phenol because the phenolics are extracted from the sour water while the crude is washed. However, the removal efficiency varies greatly depending on a number of factors, and this treatment scheme may not be a practical alternative for some refineries (48). Certain crudes, particularly California crudes, may present problems in reusing sour waters in the desalter because they produce emulsions in the desalter effluent.

Table VI-2 identifies those refineries with California crudes which recycle; the table also lists the percent of crude capacity made-up of California crudes and the percentage of reused sour waters. These data show that refineries processing California crudes do not use large percentages of sour water in the desalter. In fact, the refineries that use a large percentage of California crudes appear to reuse less sour water than those refineries that process a small percentage of California crude. However, Table VI-3 shows that five of the six plants in this analysis do reuse sour water elsewhere in the refinery.

Sour water stripper bottoms have other demonstrated uses in the petroleum refining industry (36). These include reuse as cooling tower make-up and as process wash water, both of which afford additional phenol removal due to either oxidation or extraction. The biological environment in most cooling systems is conducive to removal of 90 percent or more of the phenols present (36).

The 1977 EPA Petroleum Refining Industry Survey shows that 36 refineries reuse 100% of their treated sour waters in the desalter, while an additional 43 plants reuse at least some portion of their treated sour waters in the desalter. In addition, 32 refineries reuse treated sour waters in some other process. Of these plants, four reuse 100% of their treated sour waters as make-up to cooling towers. Table VI-3 summarizes the extent of industry reuse of treated sour waters.

The American Petroleum Institute published a document entitled "Water Reuse Studies" in August 1977 (150). This document presents methods for achieving zero discharge, including:

1. Recycle and reuse of treated effluent as well as other wastewaters;
2. Recovery and reuse of condensate streams;
3. Evaporation of wastewater with waste heat; and
4. Use of brine concentrators to eliminate high TDS streams.

The API report concludes that for grass roots refineries, "(1) engineering concepts are available which indicate complete reuse of refinery water is technically possible and (2) the capital and operating costs appear favorable for complete recycle . . . ."(150).

The recycle of treated effluent as cooling tower make-up or for other uses is certainly a viable treatment alternative and must be considered as an available BAT technology. Significant reductions in wastewater generation can decrease the quantities of pollutants discharged to navigable waters. In some cases where refinery personnel already have significantly improved their present wastewater management system (i.e., minimized cooling tower blowdown), the treated effluent to be recycled may require further treatment (i.e., softening) prior to recirculation.

In order to determine an upper limit of how much treated wastewater can be reused as cooling tower make-up, the amount of cooling tower make-up required in the industry on a plant-by-plant basis is summarized in Table VI-4. The percentage of cooling tower make-up water in the total wastewater discharged also is shown. This table has been derived from the 1977 idustry survey data base. Approximately half of the facilities have a cooling tower make-up water requirement equaling or exceeding the total refinery discharge flow.

EPA analyzed the flow informations from the 1977 survey to determine the degree of flow reduction achievable. The petroleum refineries were divided into two categories: plants presently generating wastewater equal to or less than their model flow; and those with flow rates higher than the model flow. The average of the percent flow reductions for all refineries meeting their model flow has been determined to be 52%. 36% of the refinereies have wastewater generation equal to or less than 52% of the model flow. Table VI-20 lists the refineries that are generating wastewater equal to or less than their model flow.

Refineries with wastewater generation equal to or less than their model prediction and greater than 52% of the model flow were anlayzed. The average of the percent flow reduction for these refineries is 27%. Approximately 50% of the industry is achieving this reduction.

In order to check whether the "low flow" plants (i.e. plants with discharge flow rates at or below 0.48 of BAT model flow) represent a special segment of the industry, the data from these plants have been reviewed and analyzed. Table VI-5 presents the capacities, BPT subcategories, and EPA regions for the 93 plants presently at or below 0.48 of their model flow. Tables VI-6 through VI-8 summaries the data included in Table VI-5. These data show that the size, geographical location and complexity of this segment is very similar to the industry as a whole.

END-OF-PIPE TREATMENT

This document defines end-of-pipe treatment as all wastewater treatment systems that follow an API separator or a similar oil/water separation unit. The treatment schemes described below were considered for application as BAT, BCT, and BADT in conjunction with BPT treatment and water reuse and recycle.

Biological Treatment

Biological treatment is the basic process by which at most refineries in meeting existing BPT guidelines. Excellent removal of oxygen demanding compounds (as measured by the BOD_5, COD, and TOC test methods) is being achieved at many refineries through the application of well-designed and well-operated biological treatment systems (146). This is the first step toward compliance with future BAT guidelines, regardless of their basis. This will be particularly true for those refineries which have complied with BPT requirements by drastically reducing flow while only minimal improving the treatment system.

Where it is necessary to upgrade present biological systems, there are many options available. These include compartmentalized oxidation ponds to provide preliminary mechanical aeration; revamping aerated lagoon systems into activated sludge systems; and the converting standard activated sludge systems to pure oxygen systems. Other modifications can improve the operating efficiency of particular biological treatment unit, but these require investigations on a plant-by-plant basis.

The sampling data presented in Section III indicate that biological treatment can remove organic priority pollutants to low levels (i.e. 10-100 micrograms per liter). These removals were obtained from both industrial and POTW samples as part of this study. It should be noted that the removal mechanisms have not been determined. Removals may be accomplished by air stripping and waste sludge settling as well as biological degradation.

Filtration

Filtration, a polishing step after biological treatment, also was considered as part of the model BPT treatment technology (3). The survey results indicate that 27 of the 259 respondents use filtration as part of their existing treatment scheme, including those plants where filtration precedes biological treatment. Sixteen other refineries plan to install filtration systems in the near future. Table VI-9 lists those refineries that have, or are planning to install, rapid sand or dual media filtration systems. Filtration can improve effluent quality by removing suspended solids and the BOD and COD associated with suspended material, and by removing carry-over metals that already have been precipitated and flocculated. Filtration can also improve overall treatment plant performance (130, 132, 133).

The removal of solids through filtration techniques can reduce the effluent variability of biological treatment systems. One study (30) showed that the percentage of suspended solids removed did not deteriorate with high feed content; in fact, the percent removals often increased with feed concentration. Concentration of suspended solids in the effluent rose during these situations, but not in proportion to the feed increase. Thus, one conclusion of the report was that granular media filters may be used to clarify refinery wastewaters, including occasional surges.

Another study (99) showed that filtration of refinery effluent was able to reduce the suspended solids to less than 5 mg/l for "all feed concentrations" (8-91 mg/l TSS), further supporting the fact that filters can reduce the effluent variability of biological treatment systems.

One petroleum refining company uses rapid sand filtration to treat its biological treatment plant influent (150). Biological treatment systems presently remove some suspended as well as dissolved materials. However, if filters are used prior to the biological unit to remove the suspended material not removed in primary treatment, the biological system can afford better removal of the dissolved organics with less solids generation (50). Another advantage of pre-filtration is that it allows the biological system to operate at increased sludge ages (greater than 20-40 days). High sludge ages can produce higher treatment efficiencies, fewer system upsets, and less sludge.

Granular Activated Carbon

Granular activated carbon has been used in the potable water industry for many years and has been used to remove dissolved organics in industrial and municipal wastewater treatment plants in recent years (49). Activated carbon systems have functioned both as polishing units following a biological treatment system and as the major treatment process in a physical/chemical treatment system.

The granular activated carbon system considered here consists of one or more trains of carbon columns, each train having three columns operated in series. The columns operate by rotating their positions in the train, so that the newly regenerated carbon would be in the third vessel, whereas the vessel with the most spent carbon would be the first vessel. One possible piping and equipment arrangement showing this scheme is presented in Figure VI-1. Smaller refineries may only require one or two vessels, operated manually, without the sophisticated piping arrangement shown in Figure VI-1. This simpler system serves as the basis for EPA's development of installation costs of this technology at refineries having low effluent flow rates.

EPA expects that all but the smallest systems would require on-site regeneration of carbon. Figure VI-2 is a flow diagram of one possible carbon regeneration system. Some instances may require filtration prior to the carbon units to remove suspended solids and prevent plugging of the carbon pores.

One refinery (No. 168) treats all of its wastewater with activated carbon. At this refinery, granular activated carbon has been used as the main treatment process, in that there is no biological treatment system used for organic and BOD removal before the adsorbers. The refinery has experienced operating problems with the system (many of which have been mechanical in nature), and now plans to install a biological treatment facility to replace the carbon system. The carbon treatment facilities will be preserved in case they are needed to meet future guidelines. The poor performance record at this facility should not be considered reflective of carbon systems operating as polishing units to biological treatment systems.

Powdered Activated Carbon

A new technology developed over the past several years consists of the addition of powdered activated carbon to biological treatment systems. The adsorbant quality of carbon, which has been known for many years, aids in the removal of organic materials in the biological treatment unit (144). This treatment technique also enhances color removal, clarification, and system stability, as well as BOD and COD removal (115, 116). Results of pilot testing (59, 60) indicate that this type of treatment, when used as a part of the activated sludge process, is a viable alternative to granular carbon systems.

One chemical manufacturing complex has installed a full-scale, 40 MGD powdered activated carbon system that started up during the spring of 1977 (61). This system, which includes carbon regeneration, is the basis for the cost analysis presented in section VII. A simplified flow diagram is presented in Figure VI-3. The waste sludge, which contains powdered carbon, is removed from the activated sludge system and thickened in a gravity thickener. The sludge is then dewatered in a filter press prior to being fed to the regeneration furnace. The regenerated carbon is washed in an acid solution to remove metals as well as other inorganic materials. Fresh carbon is added as make-up to replace the carbon lost in the overflow from the activated sludge process or in the regeneration system.

The powdered activated carbon system described above is a very comprehensive treatment system that includes operations which may not be required at all installations. The need for a filter press system or acid cleaning system as well as a carbon regeneration furnace should be determined on a case-by-case basis, in that these treatment steps may not be required at every refinery. Low metals content and good sludge settleability may reduce the need for the filter press or acid cleaning systems even at refineries that would regenerate the carbon on-site.

Several tests of powdered activated carbon added to petroleum refinery activated sludge systems have been reported. Rizzo reported on a plant test of carbon addition to an extended aeration treatment at the Sun Oil Refinery in Corpos Christi, Texas (150). This test tried three carbon dosages; 24 ppm, 19 ppm, and 9 ppm were tried. Test results showed that even the very small carbon dosages significantly improved BOD, COD, and TSS removals, as well as producing uniform effluent quality, a clearer effluent, and elimination of foam.

Grieves, et. al., (153) reported on a pilot plant study at the Amoco refinery in Texas City where the addition of activated carbon to the activated sludge process was evaluated in 37.9 liter (10 gallon) pilot plant aerators. Significant improvements in soluble organic carbon (53 percent), soluble COD (60 percent), NH_3-N (98 percent), and pehnolics were observed through the addition of 50 mg/l of high surface area carbon. Improvement increased with increasing carbon dosage.

Exxon researchers tried adding activated carbon to bench scale activated sludge units with somewhat less success (154). Their tests evaluated three carbon dosages which produced aerator equilibrium carbon levels of 25 to 2000 mg/l. At aerator carbon levels of 25 - 400 mg/l, no improvement was seen in the performance of the activated sludge process. However, since this represents carbon dosages of about 1 - 10 ppm, this result is not surprising, and not inconsistent with most other studies. This low dosage is usually an inadequate amount of carbon, which gets lost or overwhelmed in the system.

At higher carbon dosages, giving aerator carbon levels of 1000 mg/l or more, Exxon got positive results. In a field test, scale undisclosed, Thibault, et. al., significantly improved effluent quality and noted improvement in shock loading resistance leading to process stability. Increased removals of TOC and COD averaged 10 percent.

Another powdered activated carbon scheme has been studied (60, 145) that uses very high sludge ages (60 days or more); this allows the carbon to accumulate to high concentrations in the mixed-liquor, even though only small make-up amounts are added to the system. This approach may eliminate the costly regeneration scheme described above due to the low carbon addition rates, allowing for the disposal of spent carbon with the sludge. Considerable pilot work has been done with this concept but no full-scale system is currently operating.

Pilot tests (62) also have shown that powdered activated carbon can be used successfully with rotating biological contactors (RBC'S). Refinery No. 32, has constructed a full-scale system based upon the results of the pilot testing. EPA is investigating this system further.

Metals Removal

Metals such as copper, zinc, lead, arsenic and cadmium, may originate from many sources within a refinery and may therefore requrie end-of-pipe treatment. The development document published in March, 1974, for the copper, nickel, chromium and zinc segment of the electroplating industry (114) considered chemical precipitation and clarification to be the best practicable treatment in that industrial category. The best plants in that industry obtained the following long-term average effluent concentrations for selected metals:

Cu	0.2 mg/l
Ni	0.5 mg/l
Cr^{6+}	0.055 mg/l
Cr(T)	0.3 mg/l
Zn	0.3 mg/l
CN	0.04 mg/l

The results of the RSKERL and Burns and Roe supplemental sampling programs (see section III) show that BPT technology in the refining industry achieves metal discharges similar to or lower than the values shown above; therefore, end-of-pipe chemcial precipitation and clarification generally will not improve significantly the effluent metals concentrations in petroleum refineries over existing BPT technology. Further reductions in the concentration of metals would require advanced wastewater treatment schemes, such as ion exchange, reverse osmosis, or activated carbon (147).

With regard to chromium removal, since the chemical treatment scheme described earlier is applied as an in-plant measure, the actual discharge concentration of chromium will be lowered by the dilution of the cooling tower blowdown in the final effluent stream. Therefore, concentrations of total chromium on the order of magnitude of 0.02-0.05 mg/l may be achievable with this type of technology. (0.02-0.05 mg/l is based upon a dilution to 10-25 percent of its original concentration in the cooling tower blowdown stream, and a long-term average concentration in the blowdown streams of 0.2 mg/l as shown in the electroplating industry).

RSKERL Carbon Studies

The Robert S. Kerr Environmental Research Laboratory (RSKERL) studied carbon treatment at six refineries as part of their overall sampling program.

The granular carbon tests used four columns operating in parallel. Each column contained a different type of carbon to determine differences in performance. One column contained previously exhausted and then regenerated carbon. The other three columns contained different types of virgin carbon. Field tests were undertaken to determine which of the virgin carbons had the highest TOC removal capacity, using the isotherm testing method. The effluents from the "best" virgin carbon and the "regenerated" carbon were then tested to evaluate their removal capabilities. The inlet wastewater to the carbon columns was treated using multi-media filtration.

Tables VI-10 and VI-11 present the operating data, where available prior to the preparation of this report, for the filter and two carbon columns tested at the six refineries. RSKERL is preparing a detailed report on the process operations at each refinery with a more detailed discussion of the carbon testing program.

RSKERL also tested a powdered activated carbon system at four of the six refineries. The test unit consisted of a small activated sludge pilot unit to which powdered carbon was added on a batch basis. Tables VI-12 and VI-13 present the operating data, where available prior to the preparation of this report, for the pilot powdered activated carbon system.

It should be noted that these pilot tests are only short-term feasibility studies, due to the limited testing period and lack of repeated carbon exhaustion and regeneration. These factors tend to limit the usefulness of the tests as predictors of full-scale systems. However, this information coupled with that being generated within the petroleum refining industry (60,62) is expected to be useful in determining the potential for applicability of granular carbon and powdered activated carbon systems to remove toxic pollutants.

Ultimate Disposal Methods

The use of flow reduction and recycle methods described above will reduce the quantity of water discharged or subject to end-of-pipe treatment. None of the above described techniques willl eliminate the discharge of water. Zero discharge of water is technically achievable, however; 55 existing refineries have reported zero discharge. Table VI-14 presents information on the capacities and disposal methods employed by these 55 refineries. Out of the 55 plants, 32 use evaporation or percolation ponds, 10 use disposal wells, five use contract disposal, two use leaching beds, one uses surface spray, and six reported no wastewater generation at all.

In order to highlight the geographical and process distribution of the zero discharges, the following breakdown is provided:

Distribution by
EPA Region

Region	Number of Refineries
1	1
2	0
3	0
4	1
5	1
6	20
7	2
8	14
9	14
10	2
Total	55

Distribution by
BPT Subcategory

Subcategory	Number of Refineries
A	34
B	15
C	1
D	2
E	0
Total	3

Percolation and evaporation ponds cbe an attractive disposal methods when evaporation losses exceed rainfall. These ponds can be sized according to the annual flow, so that the inflow plus the incidentally added water (i.e., rainfall) are equal to percolation and evaporation losses. This technique is in operation at many petroleum refineries in the continental United States.

The petroleum refinery industry also practices deep-well injection. This method can be recommended only with the stipulation that extensive studies be conducted to insure environmental protection.

Irrigation or other similar land disposal techniques is a viable end-of-pipe treatment alternative. This can eliminate discharge of all or a portion of process wastewaters to navigable streams. One petroleum refinery (No. 26) already employs this or a similar technology.

The various ultimate disposal methods discussed above are viable treatment alternatives. However, their application is highly dependent on local conditions (i.e., rainfall, availability of a suitable deep-well, availability of land, availability of land suitable for irrigation). Plants which are not located in an area with the above described conditions can also achieve zero discharge. Technology for ultimate disposal for these plants is based on force evaporation. Heat is used to evaporate the water. The steam is condensed and reused as make-up water to the refinery while the brine (slurry) stream is transformed into a solid state in a flash dryer. This zero discharge treatment scheme is described in detail in the 1977 American Petroleum Institute Reprot (150). The cost of this end-of-pipe treatment scheme is related to the flow. In costing this zero discharge technology, the plant is assumed to implement the various recycle/reuse scheme discussed earlier. Although the forced evaporation system is not used currently in the refining industry, it is being used in power plants which have compatible flow rates.

EXISTING TECHNOLOGY

Existing BPT guidelines are based upon end-of-pipe treatment systems consisting of biological treatment, followed by rapid sand or multimedia filtration or an equivalent polishing step, and in-plant control practices widely used within the petroleum refining industry that include the following:

1. Installation of sour water strippers to reduce the sulfide and ammonia concentrations entering the treatment plant.

2. Elimination of once-through barometric condenser water by using surface condensers or recycle systems with oily water cooling towers.

3. Segregation of sewers so that unpolluted storm runoff and once-through cooling waters are not treated normally with the process and other polluted waters.

4. Elimination of polluted once-through cooling water, by monitoring and repair of surface condensers or by use of wet and dry recycle systems.

The National Commission on Water Quality had a contractor's report (65) prepared in 1975 on the petroleum refining industry that included a status of the treatment technology and water usage of most of the refineries in the United States. The data were obtained for the year 1973, and present a picture of the industry as it appeared at the time the BPT guidelines were promulgated.

The 1977 EPA Petroleum Refining Industry Survey obtained data for the calendar year 1976. Table VI-15 presents a comparison of the industry's wastewater treatment practices for 1973 (National Commission Data) and 1976 (1977 survey). The following is a list of treatment processes included in Table VI-11:

Corrugated Plate Separator	(Corr. Plate Sep.)
Dissolved Air Flotation	(DAF)
Other Flotation Systems	(OAF)
Chemical Flocculation	(Chemical Floc.)
Pre-Filtration	-
Stabilization Pond	(Stab. Pond)
Aerated Lagoon	(Aerated Lag.)
Activated Sludge	(Act. Sludge)
Trickling Filter	(Trick.Filter)
Rotating Biological Contactor	(RBC)

Other Organics Removal	(Other Org. Rem.)
Filtration	-
Polishing Pond	(Pol. Pond)
Carbon Adsorption	(Act. Carbon)
Evaporation or Percolation Pond	(Evap. or Perc. Pond)

Table VI-16 summarizes the treatment systems listed in Table VI-15, showing the progress made by the industry in installing end-of-pipe treatment technology. The treatment units shown in these tables do not necessarily treat all of a particular refinery's wastewaters, and many treatment schemes may be pretreatment systems for discharge to a POTW.

The word "none" where indicated in Table VI-15 refers to refineries that do not have any of the treatment operations considered in this analysis. However, these plants may treat their wastewaters through gravity oil separation techniques.

A definitive list of refineries that have filtration or activated carbon operations is significant. Those refineries that included filtration or activated carbon in their responses to the 1977 survey were screened to eliminate those systems that are treating only a minor portion of their wastewater, such as stormwater runoff or boiler blowdown. This approach has reduced the total number of refineries listed as having these types of treatment to just those plants which treat a significant portion of their wastewater through the application of this technology.

Table VI-16 shows that there has been a marked increase in the number of refineries having BPT-type technology in-place in 1976. The number of pretreatment operations, such as DAF, other flotation systems, and chemical flocculation shows a significant increase, indicating the importance of these unit operations in meeting BPT limitations.

Table VI-15 also presents data on water usage, including once-through cooling water, during the two one-year periods surveyed. The comparison used water usage, rather than wastewater production because data on wastewater production were not available for the year 1973. For those refineries with data available for both survey years, there was an overall flow reduction of approximately 16%. This percentage would undoubtedly be greater if conditions remained constant. However, many refineries have expanded their operations or increased their complexity by adding additional process units between 1973 and 1976; this would minimize the effect of water reduction on a unit basis. Many of the flow reductions appear to result from a reduction in the use of once-through cooling water.

Tables VI-17 and VI-18 summarize the future modifications planned by the survey respondents. Table VI-17 indicates planned wastewater reduction techniques along with expected flow reductions. Table VI-18 presents a summary of future modifications to wastewater treatment plants.

Effluent Concentrations

The effluent concentration achievable by BPT treatment technologies is discussed in the 1974 Development Document. The sampling results from the 17 screening plants are in agreement with the original findings with exception to phenol. The concentrations and variability factors used in the BPT regulations are:

	Concentration mg/l	Variability Factors daily	monthly
Phenol	.1	3.5	1.7
Chromium (total)	.25	2.9	1.7
Chromium (hexavalent)	.02	3.1	1.4
BOD	15	3.2	1.7
TSS	10	3.3	2.1
O&G	5	3.0	1.6

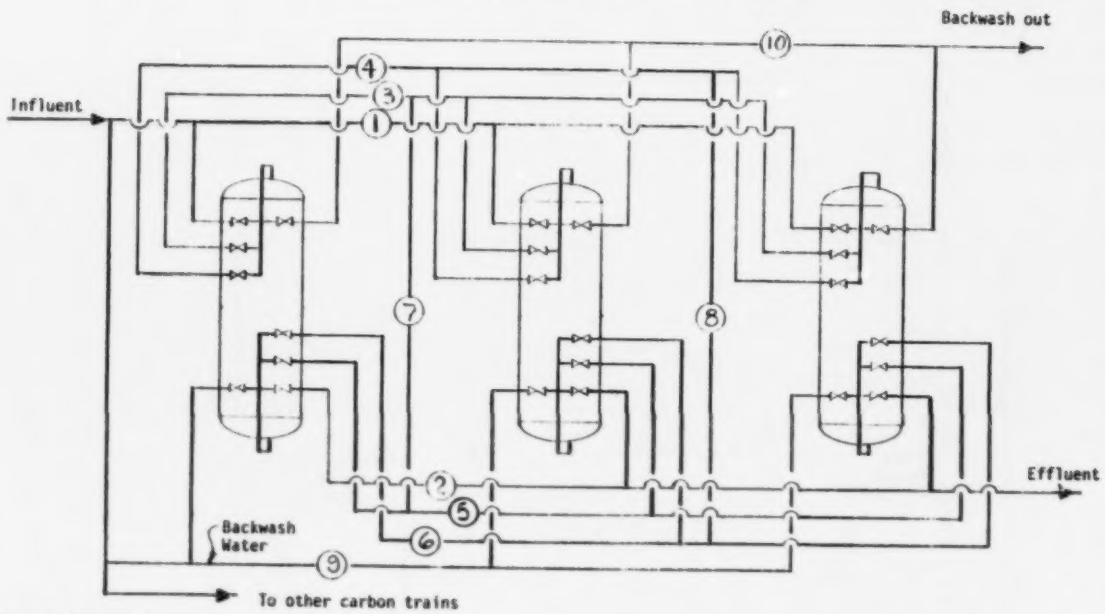
The screening sampling results indicate an average reduction of phenols to 19 ug/l. Additional data are being gathered to better define the variability factors for phenol at the 19 ug/l level.

The 1974 development document concluded that the influent concentrations do not affect the effluent quality of the BPT wastewater treatment system. This conclusion is indirectly supported by the screening sampling results. The flow rate and the effluent concentration from each screen sampling refinery were analyzed.

Table VI-19 presents a detailed summary of the discharge data from 16 screening plants; including the percentage of actual discharge flow to model flow, as well as effluent concentrations for BOD, TSS, TOC and Oil and Grease. The table also presents analysis of the correlations of these factors. These data show that there is no correlation between discharge flow and final effluent concentrations after BPT treatment.

FIGURE VI-1

Flow Diagram of a Granular Activated Carbon System


Backwash out
Influent
Effluent
Backwash Water
To other carbon trains
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)

Piping Explanation

(1) Main influent header (to 1st tank in series)
(2) Main effluent header (from 3rd tank in series)
(3) Influent header to 2nd tank in series
(4) Influent header to 3rd tank in series
(5) Effluent header from 1st tank in series
(6) Effluent from 2nd tank in series
(7) Connection between #3 and #5 headers
(8) Connection between #4 and #6 headers
(9) Backwash inlet header
(10) Backwash outlet header

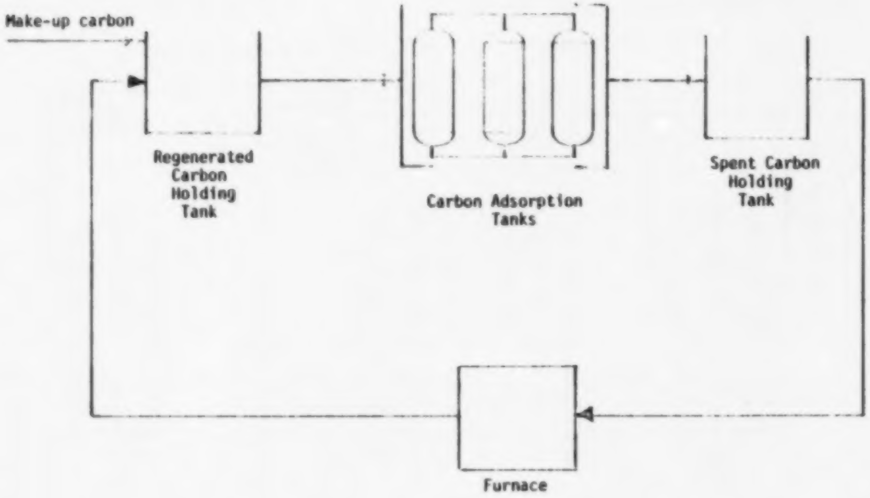

Make-up carbon
Regenerated Carbon Holding Tank
Carbon Adsorption Tanks
Spent Carbon Holding Tank
Furnace

FIGURE VI-2

Carbon Regeneration System

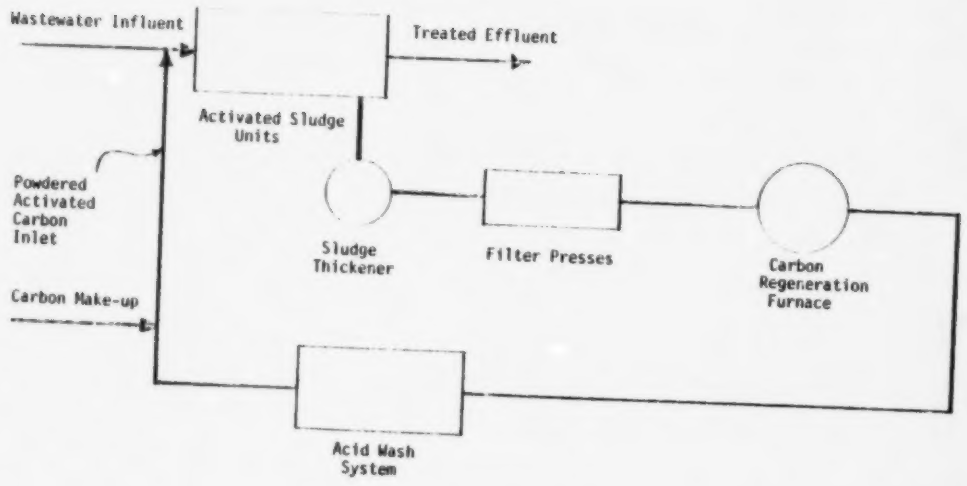

Wastewater Influent
Treated Effluent
Activated Sludge Units
Powdered Activated Carbon Inlet
Sludge Thickener
Filter Presses
Carbon Regeneration Furnace
Carbon Make-up
Acid Wash System

FIGURE VI-3

Flow Diagram of One PACT Treatment Scheme

TABLE VI-1
SOUR WATER TREATMENT IN PETROLEUM REFINERIES

REFINERY NUMBER	SINGLE STAGE STRIPPING	TWO STAGE STRIPPING	OXIDIZING	OTHER
1	X			
2				X
3			X	
8				X
10				X
13	X		X	
15	X			
16	X			
18	X			
20	X			
24			X	
25	X		X	
29	X		X	X
30	X			
31				X
32	X			
33	X		X	
36			X	
37	X			
38	X		X	X
39	X			
40	X	X	X	
41	X	X	X	
42			X	
43	X		X	
45	X			
46	X		X	
49	X			
50		X		
51	X	X		
53				X
55	X			
56			X	X
57				X
59	X			
60		X		
61	X			
62	X			
63	X			X
64	X			
65	X			
67	X			
68	X			
70			X	
71	X			
72			X	
73	X			
74	X			
76	X			
77	X			
78			X	
80	X			
81	X			
83	X	X		

TABLE VI-1 (Continued)
SOUR WATER TREATMENT IN PETROLEUM REFINERIES

REFINERY NUMBER	SINGLE STAGE STRIPPING	TWO STAGE STRIPPING	OXIDIZING	OTHER
84	X			
85	X			
86	X			
87				X
88				X
94	X			
96	X			
98	X			
102	X			
103			X	
104				X
105				X
106				X
107			X	
108		X		
109				X
111	X			
112				X
113	X			X
114	X		X	
115	X			
116		X		
117	X			
121	X		X	X
122	X			
124	X			
125	X			
126	X			
127	X			
129			X	X
130	X			
131	X			
132	X			
133	X		X	
134	X			
139				X
142	X			
143	X			X
144	X			
147	X			
149		X		X
150		X		
151	X			
152	X			
153	X			
156	X			
157	X			
158	X			
159	X			
160	X			
161		X		
162	X			
163	X			
165	X			

TABLE VI-1 (Continued)
SOUR WATER TREATMENT IN PETROLEUM REFINERIES

REFINERY NUMBER	SINGLE STAGE STRIPPING	TWO STAGE STRIPPING	OXIDIZING	OTHER
166	X			
167	X			
168	X			
169		X		
174				X
175	X			
176				X
179	X			
180	X			
182	X			
183	X			
184	X			
185	X			
186		X		
187	X			
188	X			
190			X	
194	X			
195	X			
196	X	X		
197				X
200	X			
203		X		
204		X		
205	X			
208	X	X		
209	X			
210			X	
211	X			
212	X			
213				X
216	X		X	
221	X			
222	X			
224	X			
225	X			
226	X			
227	X			
228	X			
230	X			
232	X		X	
233	X			
234	X			
235	X			
237				X
238	X	X	X	
241	X			
243	X			
245	X			
246	X			
252	X			
255	X		X	X
256	X			
257	X			

TABLE VI-1 (Continued)

SOUR WATER TREATMENT IN PETROLEUM REFINERIES

REFINERY NUMBER	SINGLE STAGE STRIPPING	TWO STAGE STRIPPING	OXIDIZING	OTHER
258	X			
259	X			
261	X			
265	X			
309	X			

TABLE VI-2

Effect of California Crudes on Reuse of Sour Waters

Ref. No.	State	Crude Source	Percent Crude Capacity	Percent Sour Water to Desalter
13	CA	L.A. Basin	17	26
32	CA	California	49	12.5
37	CA	San Joaquin Val, CA	39.6	17
		Coalinga, CA	23.0	
38	CA	California	28.1	≈30
		California	20.2	
		California	15.7	
		California	1.2	
40	CA	California	20	60
		California	10	
41	CA	CA Midway Waxy	35	25
		CA Mid Spec.	10	

TABLE VI-3

REUSE OF SOUR WATERS
INDUSTRY STATUS

REFINERY NUMBER	PERCENT REUSE IN DESALTER	PERCENT OTHER REUSE
2	100.00	0.0
13	26.00	13.00
20	0.0	29.10
24	100.00	0.0
29	0.0	30.00
30	0.0	UNKNOWN
32	12.50	18.90
37	17.00	17.00
38	UNKNOWN	0.0
40	60.00	22.00
41	25.00	27.00
49	100.00	0.0
51	10.00	20.00
52	UNKNOWN	0.0
53	0.0	100.00
55	100.00	0.0
57	0.0	28.50
59	90.00	10.00
60	48.00	15.00
61	51.00	10.00
62	70.00	0.0
65	55.60	25.40
67	100.00	0.0
68	74.00	26.00
71	100.00	0.0
72	0.0	59.00
73	0.0	100.00
76	100.00	0.0
80	0.0	100.00
81	87.00	0.0
83	100.00	0.0
85	59.00	0.0
86	100.00	0.0
94	100.00	0.0
98	88.00	12.00
104	10.00	0.0
111	UNKNOWN	0.0
114	60.00	0.0
115	85.30	0.0
116	60.00	0.0
121	0.0	9.00
122	58.00	0.0
126	0.0	30.00
130	30.00	0.0
131	62.00	28.00
132	0.0	6.00
142	100.00	0.0
143	100.00	0.0
144	100.00	0.0
145	0.0	100.00
147	100.00	0.0
149	100.00	0.0
150	100.00	0.0
151	95.00	0.0

TABLE VI-3 (Continued)

REUSE OF SOUR WATERS
INDUSTRY STATUS

REFINERY NUMBER	PERCENT REUSE IN DESALTER	PERCENT OTHER REUSE
153	20.00	80.00
155	35.00	0.0
156	50.00	50.00
157	0.0	8.20
159	50.00	0.0
160	100.00	0.0
161	90.00	10.00
163	100.00	0.0
165	100.00	0.0
169	87.00	0.0
179	100.00	0.0
182	0.0	15.00
183	100.00	0.0
184	66.00	0.0
186	80.00	0.0
187	100.00	0.0
188	73.00	27.00
194	80.00	0.0
196	40.00	0.0
200	100.00	0.0
203	40.00	0.0
204	100.00	0.0
205	100.00	0.0
209	100.00	0.0
211	100.00	0.0
216	18.00	0.0
224	100.00	0.0
225	100.00	0.0
227	75.00	25.00
228	100.00	0.0
230	100.00	0.0
232	60.00	40.00
233	50.00	0.0
234	UNKNOWN	0.0
241	85.00	0.0
243	99.99	0.0
252	80.00	0.0
256	100.00	0.0
257	100.00	0.0
258	100.00	0.0
259	100.00	0.0
265	100.00	0.0
305	20.00	80.00

TABLE SECTION VI-4

COOLING TOWER MAKE-UP FLOW RATES IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	PERCENT COOLING BY BTU BY COOLING TOWERS
1	0.059600	0.313684	94.0000
2	0.114800	2.125925	100.0000
3	0.0	0.0	100.0000
4	NOT APP.	NOT APP.	0.0
6	NOT APP.	NOT APP.	0.0
7	0.107000	0.648485	70.1000
8	0.010000	2.000000	30.0000
9	0.025000	0.694444	UNKNOWN
10	0.020000	0.400000	UNKNOWN
11	2.909999	1.939999	94.0000
12	0.500000	0.723589	UNKNOWN
13	7.303997	1.446336	95.0000
13	7.303997	1.446336	31.5000
15	0.084500	0.554099	100.0000
16	0.382100	1.179320	72.0000
17	0.018500	0.557229	40.0000
18	0.108000	0.473684	UNKNOWN
19	0.013000	3.037382	100.0000
20	1.450000	0.759162	30.0000
21	0.298000	4.382351	UNKNOWN
22	0.094500	1.049999	73.0000
23	NOT APP.	NOT APP.	0.0
24	0.350000	1.166666	15.0000
25	0.867000	1.791321	58.0000
26	0.297000	1.993288	79.0000
29	3.419997	0.914438	75.0000
30	0.193000	0.814277	100.0000
31	> 0.0	> 0.0	UNKNOWN
32	4.969995	0.842372	76.8000
33	0.650000	1.633164	100.0000
35	NOT APP.	NOT APP.	0.0
36	0.036000	1.090908	98.5000
37	6.808996	2.885168	43.0000
38	3.290996	1.073734	80.0000
39	0.165000	1.092714	UNKNOWN
40	6.614997	0.848076	90.0000
41	6.621992	0.705969	4.5000
42	0.030000	0.874126	UNKNOWN
43	3.769996	1.314045	62.9000
44	0.0	0.0	95.0000
45	> 4.348996	> 1.363321	53.6000
46	1.462999	1.116793	50.0000
48	0.140500	0.231848	95.0000
49	0.650000	UNKNOWN	65.0000
50	> 0.235000	> 1.525973	80.0000
51	NOT APP.	NOT APP.	0.0
52	NOT APP.	NOT APP.	0.0
53	0.050000	0.200000	98.0000
54	0.030000	1.764706	100.0000
55	NOT APP.	NOT APP.	0.0
56	1.600000	1.225115	81.0000
57	9.699997	0.941747	89.0000
58	1.514149	1.058845	99.0000
59	1.825500	1.659544	47.8000

TABLE VI-4 (Continued)

COOLING TOWER MAKE-UP FLOW RATES IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	PERCENT COOLING BY BTU BY COOLING TOWERS
60	3.052498	1.568117	60.0000
61	4.599999	1.742423	47.0000
62	5.659997	1.179166	74.0000
63	1.355000	0.496337	91.4100
64	4.308998	0.897708	66.0000
65	2.484499	0.690139	40.0000
66	0.000050	UNKNOWN	100.0000
67	8.829994	0.416706	65.6000
68	8.348999	1.717900	74.4000
70	0.0	0.0	UNKNOWN
71	0.359000	1.486542	100.0000
72	0.021000	0.138158	10.0000
73	0.468000	0.605433	75.0000
74	0.471500	2.357499	95.0000
76	1.933998	0.848245	86.5000
77	0.630000	2.282607	59.0000
78	0.075500	0.111029	90.0000
79	0.0	UNKNOWN	UNKNOWN
80	2.129998	9.260860	85.4000
81	0.776500	0.641735	100.0000
82	0.216000	0.375000	100.0000
83	2.929999	1.197873	60.0000
84	2.204995	1.304730	75.0000
85	5.394799	1.639756	80.0000
86	0.440950	1.274422	97.0000
87	NOT APP.	NOT APP.	0.0
88	0.735000	3.223682	89.2000
89	0.0	0.0	28.0000
90	0.017000	0.377778	60.0000
91	0.005000	0.416667	UNKNOWN
92	> 6.552999	> 0.587186	56.0000
93	0.0	0.0	UNKNOWN
94	1.728000	0.941176	86.5000
95	0.0	0.0	100.0000
96	19.014984	1.605995	100.0000
97	0.014040	UNKNOWN	UNKNOWN
98	4.289999	1.656370	39.4000
99	NOT APP.	NOT APP.	0.0
100	NOT APP.	NOT APP.	0.0
102	0.0	0.0	0.9000
103	> 0.025000	> 0.396825	UNKNOWN
104	8.384995	1.128531	71.0000
105	NOT APP.	NOT APP.	0.0
106	2.250000	1.069391	30.0000
107	0.045000	1.499999	100.0000
108	0.126000	2.863636	99.0000
109	0.200000	0.833333	7.6000
110	NOT APP.	NOT APP.	0.0
111	2.842497	1.799048	46.0000
112	0.302500	1.490147	35.0000
113	0.529500	0.957505	49.4000
114	0.320000	1.280000	78.0000
115	1.983199	0.708285	58.8000
116	0.864000	0.720000	40.0000

TABLE VI-4 (Continued)

COOLING TOWER MAKE-UP FLOW RATES IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	PERCENT COOLING BY BTU BY COOLING TOWERS
117	1.450000	1.435642	99.0000
118	0.036500	1.013887	30.0000
119	0.100500	0.670000	28.0000
120	0.175000	1.590908	30.0000
121	4.250000	0.944444	65.0000
122	3.323500	0.519297	97.0000
124	0.975999	2.054735	100.0000
125	0.766000	1.725224	60.0000
126	0.400000	0.061728	22.0000
127	0.090000	0.520231	99.0000
128	NOT APP.	NOT APP.	0.0
129	0.066600	0.665999	UNKNOWN
130	NOT APP.	NOT APP.	0.0
131	0.330000	0.114583	20.0000
132	1.599999	0.156648	10.0000
133	5.160996	0.650819	85.0000
134	0.0	0.0	62.0000
135	> 0.0	UNKNOWN	UNKNOWN
136	0.378000	1.321678	100.0000
137	0.0	0.0	100.0000
138	0.466000	0.647222	1.0000
139	> 0.071000	> 5.071427	99.9000
140	0.222000	2.018181	70.0000
141	0.0	0.0	100.0000
142	0.502500	0.317235	66.5000
143	0.030000	0.025000	2.0000
144	0.759500	1.161314	100.0000
145	0.004500	UNKNOWN	100.0000
146	0.300000	3.225806	UNKNOWN
147	1.695000	2.942707	89.0000
148	> 0.126500	> 0.790625	100.0000
149	0.740000	0.627650	77.0000
150	NOT APP.	NOT APP.	0.0
151	4.150000	1.044288	61.7000
152	3.070000	0.366348	35.0000
153	5.792998	1.489202	63.0000
154	0.063000	0.063000	UNKNOWN
155	0.391700	2.266782	100.0000
156	1.697997	1.697997	60.0000
157	4.119996	2.049748	88.9000
158	0.570800	1.041605	71.5000
159	0.199500	0.720216	60.0000
160	0.328000	1.874285	100.0000
161	2.114997	3.253841	90.0000
162	2.115499	0.863469	UNKNOWN
163	2.732998	2.635486	88.0000
164	0.030000	1.363636	100.0000
165	0.595400	2.053102	49.8000
166	0.050000	0.454545	67.0000
167	3.864999	0.757843	70.0000
168	1.240000	0.430555	200.0000
169	6.794998	0.783737	90.0000
172	0.772000	0.839130	91.3000
173	0.0	0.0	UNKNOWN

TABLE VI-4 (Continued)

COOLING TOWER MAKE-UP FLOW RATES
IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	PERCENT COOLING BY BTU BY COOLING TOWERS
174	NOT APP.	NOT APP.	0.0
175	10.787498	0.364521	UNKNOWN
176	0.086000	0.184986	33.0000
177	0.028000	0.036601	75.0000
179	0.632700	2.243616	82.0000
180	1.870998	0.676183	98.7500
181	20.876480	1.301526	49.0000
182	6.599497	1.031171	70.0000
183	2.169648	3.390075	59.7000
184	4.675997	3.438233	75.0000
185	1.771500	2.116487	95.0000
186	2.574697	1.418566	71.0000
187	3.244994	4.203360	60.0000
188	> 4.653500	> 1.911087	80.0000
189	0.0	0.0	UNKNOWN
190	0.085000	2.560240	70.0000
191	2.545500	5.606828	100.0000
192	> 0.028000	> 0.198582	100.0000
193	0.0	0.0	UNKNOWN
194	11.303490	0.664911	79.0000
195	0.0	0.0	UNKNOWN
196	16.445465	0.888944	91.3000
197	0.002000	0.250000	100.0000
199	0.017200	UNKNOWN	UNKNOWN
200	1.694998	2.769604	70.0000
201	2.156999	2.270524	69.0000
202	0.009500	95.000000	100.0000
203	10.209991	0.789026	65.0000
204	5.268191	1.560205	75.0000
205	2.818796	1.156192	90.6000
206	12.500000	134.408600	100.0000
207	0.180000	2.535211	90.0000
208	2.844998	0.570140	47.5000
209	0.413500	1.759574	40.0000
210	0.137000	3.512819	79.9000
211	0.679049	0.834726	UNKNOWN
212	1.763000	2.507822	65.0000
213	0.038880	0.762353	35.0000
214	0.0	0.0	UNKNOWN
215	0.0	0.0	UNKNOWN
216	16.502472	0.808945	78.0000
218	7.800000	UNKNOWN	100.0000
219	1.939999	1.616665	63.0000
220	0.022000	0.916667	100.0000
221	0.0	0.0	99.5000
222	0.860000	2.457141	100.0000
224	0.0	0.0	UNKNOWN
225	1.679999	1.411764	97.9000
226	0.0	0.0	29.8000
227	1.483199	1.167872	80.0000
228	0.364500	1.752403	100.0000
229	0.113500	5.456731	100.0000
230	1.150000	1.642857	88.0000
231	NOT APP.	NOT APP.	0.0

TABLE VI-4 (Continued)

COOLING TOWER MAKE-UP FLOW RATES IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	PERCENT COOLING BY BTU BY COOLING TOWERS
232	0.0	0.0	2.5000
233	2.450000	2.450000	45.0000
234	0.0	0.0	UNKNOWN
235	2.149999	1.433332	83.0000
236	0.016000	0.133333	UNKNOWN
237	0.016000	0.571428	90.0000
238	1.999999	1.044931	84.5000
239	0.055000	0.436508	47.0000
240	0.180000	0.300000	UNKNOWN
241	0.324000	0.490909	100.0000
242	0.450000	0.703125	95.0000
243	0.524000	3.119045	69.0000
244	0.612000	0.334426	99.0000
245	0.707000	1.178332	99.6000
246	0.182500	0.323009	UNKNOWN
247	0.558800	2.696910	100.0000
248	0.0	0.0	100.0000
249	0.380000	0.456731	50.0000
250	0.0	UNKNOWN	UNKNOWN
251	NOT APP.	NOT APP.	0.0
252	0.009000	0.064748	90.0000
253	0.0	0.0	UNKNOWN
254	0.0	UNKNOWN	UNKNOWN
255	0.0	0.0	UNKNOWN
256	0.040000	0.109589	100.0000
257	NOT APP.	NOT APP.	0.0
258	0.792000	0.792000	40.0000
259	NOT APP.	NOT APP.	0.0
260	NOT APP.	NOT APP.	0.0
261	0.640000	1.361701	90.0000
264	0.0	0.0	UNKNOWN
265	1.296000	1.169674	UNKNOWN
266	NOT APP.	NOT APP.	0.0
278	0.0	UNKNOWN	UNKNOWN
291	0.506000	3.563379	90.0000
292	NOT APP.	NOT APP.	0.0
295	0.610600	2.361176	90.0000
296	NOT APP.	NOT APP.	0.0
298	> 0.0	> 0.0	100.0000
302	NOT APP.	NOT APP.	0.0
303	0.0	UNKNOWN	UNKNOWN
305	> 0.040000	> 0.863931	100.0000
307	> 0.0	UNKNOWN	UNKNOWN
308	> 0.0	UNKNOWN	UNKNOWN
309	> 0.720000	> 0.743801	100.0000

> - DUE TO UNKNOWN MAKE-UP FLOWS FOR SOME COOLING TOWERS, THE NUMBER IS GREATER THAN SHOWN

NOT APP. - NOT APPLICABLE BECAUSE OF 0.0 % COOLING BY COOLING TOWERS

TABLE VI-5

PROFILE OF PLANTS AT OR BELOW 48 PERCENT OF MODEL FLOW (LEVEL 2 PLANTS)

Refinery No.	Region No.	BPT Subcategory	Crude Capacity (MBD)	Fraction of Model Flow
176	3	B	52.	.483
98	6	B	202.3	.480
62	5	D	295.0	.480
144	8	B	49.9	.478
33	9	A	44.0	.477
185	6	B	75.0	.477
53	4	A	14.0	.476
15	9	B	32.0	.473
86	4	B	25.0	.472
113	5	B	42.0	.471
37	9	E	103.0	.470
60	5	B	195.0	.468
305	6	A	13.	.467
106	6	B	154.9	.464
9	6	A	3.5	.458
207	6	A	46.	.455
23	9	A	16.	.452
259	2	C	655.0	.451
161	6	B	51.	.449
119	4	A	11.	.444
14	9	B	12.4	.439
16	9	A	48.0	.438
114	5	B	24.0	.432
206	6	A	36.5	.431
77	7	B	23.2	.430
6	10	A	22.0	.427
124	8	B	42.0	.404
2	4	A	20.0	.399
26	9	B	17.	.393
158	6	B	54.6	.388
233	10	B	100.	.372
210	6	B	18.1	.361
264	5	A	23.	.358
298	1	A	15.	.349
195	6	A	1.0	.332
187	6	C	56.0	.332
18	9	A	10.	.329
90	6	A	2.2	.329
125	8	B	56.	.322
160	6	B	23.5	.312
55	9	A	60.3	.311
1	4	A	30.0	.310
213	6	A	21.6	.301
209	6	B	35.0	.299
74	7	B	22.5	.297
155	6	B	14.5	.295
148	5	A	20.0	.285

TABLE VI-5 (Continued)

Refinery No.	Region No.	BPT Subcategory	Crude Capacity (MBD)	Fraction of Model Flow
137	6	A	4.5	.283
147	5	B	65.0	.283
108	3	A	13.5	.279
22	9	A	11.	.270
260	4	A	3.	.267
140	6	B	19.0	.253
50	8	B	21.5	.251
202	6	A	3.5	.250
118	4	A	6.0	.248
179	6	B	26.	.244
243	5	B	42.0	.232
8	9	A	5.0	.227
103	6	A	36.	.226
25	9	B	53.8	.222
310	8	A	3.0	.217
191	6	B	53.5	.207
36	9	A	17.0	.203
3	4	A	1.2	.192
54	4	A	3.	.179
10	6	D	6.0	.174
237	10	A	5.0	.165
165	6	B	60.	.153
17	9	A	9.5	.151
220	6	A	10.0	.149
49	8	B	33.5	.141
80	7	B	52.0	.139
99	6	B	28.7	.136
107	3	A	17.	.096
97	6	B	50.0	.085
254	8	A	1.	.083
229	8	B	5.6	.075
19	9	A	2.5	.055
193	6	A	3.2	.050
218	6	A	6.0	.029
31	9	A	12.	.029
141	6	A	4.0	.022
4	10	A	13.0	.011
302	6	A	2.2	.010
248	8	A	1.	.003
135	6	A	2.5	.000
250	8	A	1.	.000
251	8	A	0.5	.000
278	4	A	3.	.000
296	6	A	10.0	.000
303	6	A	1.	.000
307	10	A	0.8	.000
308	8	A	0.1	.000

TABLE VI-6

GEOGRAPHICAL BREAKDOWN OF LEVEL 2 PLANTS

EPA REGION	PERCENT OF PLANTS DISCHARGING LESS THAN 48 PERCENT OF MODEL FLOWS	PERCENT OF PLANTS IN TOTAL INDUSTRY
1	1	1
2	1	4
3	3	6
4	11	6
5	9	13
6	37	34
7	3	5
8	13	12
9	17	14
10	5	5

TABLE VI-7

SUMMARY OF CRUDE CAPACITIES FOR LEVEL 2 PLANTS

CRUDE CAPACITY (MBD)	PERCENT OF PLANTS DISCHARGING LESS THAN 48 PERCENT OF MODEL FLOW	PERCENT OF PLANTS IN TOTAL INDUSTRY
0 - 25	63	47
25 - 100	31	34
100 - 200	3	12
> 200	3	7

TABLE VI-8

BPT SUBCATEGORY BREAKDOWN OF LEVEL 2 PLANTS

SUBCATEGORY	PERCENT OF PLANTS DISCHARGING LESS THAN 48 PERCENT OF MODEL FLOWS	PERCENT OF PLANTS OF TOTAL INDUSTRY
A	57	38
B	38	40
C	2	9
D	2	8
E	1	4
U	0	1

TABLE VI-9

Refineries that Utilize, or Plan to Utilize Filtration Systems

Presently Installed

12
23
44
50
53
60
92
100
107
115
118
119
120
133
134
153
168
181
187
199
201
211
219
225
227
232
255

Future Installations

11
32
42
44
57
67
70
102
105
122
132
152
168
204
212
232

TABLE VI-10
ANALYTICAL RESULTS
FOR
RSKERL GRANULAR ACTIVATED CARBON STUDY, TRADITIONAL POLLUTANTS

Sample	- Day	BOD-1	BOD-3	COD	TOC	TSS	NH$_3$	Cr^{+6}	S^{-2}	O&G	pH
		Concentration (mg/l)									
Refinery B											
Filter influent	-6	L15	L15	120	53	22	22	L.02	.1	6	7.3
	-9	L30	L30	110	43	36	15	L.02	.5	4	7.7
	-12	10	L30	110	37	32	16	.02	.4	7	7.6
	-15	L30	L30	100	40	26	12	L.02	L.1	14	7.4
Filter effluent	-6	L15	L15	99	45	12	22	L.02	.1	14	7.4
	-9	L30	L30	120	45	34	15	.02	.4	6	7.6
	-12	15	L30	100	37	28	16	L.02	.3	7	7.9
	-15	L30	L30	84	33	10	11	L.02	.1	7	7.4
Virgin carbon effluent	-6	L6		16	17	4	44	L.02	.1	7	7.4
	-9	L12		31	11	4	16	L.02	.2	9	7.5
	-12	L12		13	9	6	16	L.02	.1	5	7.6
	-15	L12		16	10	4	12	L.02	.1	7	7.3
Reg. carbon effluent	-6	L6		16	18	4	22	L.02	.2	17	7.3
	-9	L12		31	12	4	16	L.02	.2	4	7.5
	-12	L12		24	11	5	16	L.02	L.1	6	7.4
	-15	L12		28	15	4	12	L.02	.1	5	7.3
Refinery H											
Filter influent	-6	L6		24	40	5	5.6	L.02	.1	5	7.5
	-9	L12		35	13	4	4.5	L.02	.2	11	7.4
	-12	L12		40	21	5	3.9	L.02	.2	19	7.5
	-15	L12		39	15	15	17	L.02	.2	5	7.2
Filter effluent	- 6	L6		20	36	4	5.6	.02	.1	5	7.4
	-9	L12		31	14	1	4.5	L.02	.2	5	7.4
	-12	L12		32	18	3	3.9	L.02	.1	10	7.7
	-15	L12		33	8	7	2.2	L.02	.2	13	7.3
Virgin carbon effluent	-6	L3		12	10	2	5.6	L.02	.2	8	7.3
	-9	L6		12	6	2	3.4	L.02	.2	8	7.5
	-12	L12		12	10	4	4.5	L.02	.2	6	8.2
	-15	4		15	8	7	2.8	.02	.2	10	7.4

TABLE VI-10 (Continued)

	Concentration (mg/l)									
Sample - Day	BOD-1	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH
Refinery H - Cont'd										
Reg.carbon effluent -6	L3		11	10	2	5.6	L.02	.1	9	7.3
-9	L6		11	3	1	3.9	L.02	.2	2	7.4
-12	L12		10	13	6	4.5	L.02	.2	7	7.6
-15	L6		11	14	7	3.4	L.02	.2	7	7.4
Refinery K										
Filter influent -6	L30		170	58	66	6.2	L.02	.7	42	7.1
-9	L30		96	32	33	11	L.02	.8	21	7.4
-12	L6		140	40	52	10	L.02	.6	42	7.5
Filter effluent -6	L12		60	25	7	5.6	L.02	.5	5	7.1
-9	L12		56	18	1	11	L.02	.5	8	7.4
-12	L12		52	23	4	9.0	L.02	.5	6	7.3
Virgin carbon effl.-6	L6		1	7	2	5.6	L.02	.2	6	7.3
-9	L6		13	6	L1	11	L.02	.5	9	7.2
-12	L6		12	11	2	9.0	L.02	.6	5	7.3
Reg.carbon effluent -6	L6		15	9	2	5.6	L.02	.3	L1	7.1
-9	L6		16	8	1	11	L.02	.5	8	7.2
-12	120		15	12	L1	9.5	L.02	.6	7	7.5
Refinery M										
Filter influent -6	L12		96	17	10	L1.0	L.02	.6	17	7.7
-9	L12		75	19	11	L1.0	L.02	.5	14	7.6
-12	L12		150	19	7	L1.0	L.02	.5	5	7.5
Filter effluent -6	L6		56	15	6	L1.0	L.02	.5	9	7.6
-9	L3		67	22	2	L1.0	L.02	.3	17	7.6
-12	L6		42	15	1	L1.0	L.02	.4	10	7.6
Virgin carbon effl.-6	L6		11	5	2	L1.0	L.02	.5	9	7.4
-9	L3		10	7	L1	L1.0	L.02	.3	13	7.4
-12	L3				L1		L.02	.4	6	7.5
Reg.carbon effluent-6	L6		14	4	2	L1.0	L.02	.5	10	7.4
-9	L6		8	10	1	L1.0	L.02	.4	11	7.4
-12	L6		13	5	1	L1.0	L.02	.4	3	7.3

TABLE VI-10 (Continued)

Sample - Day	Concentration (mg/l) BOD-1	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH
Refinery O										
Filter influent -6	12	13	130	20	42	1.4	.02	.8	18	7.9
-9	10	10	120	55	28	2.5	L.02	.4	6	8.2
-12	10	6	130	41	34	3.4	L.02	.3	30	8.2
-15	10	8	120	38	22	1.7	.02	.3	18	8.4
Filter effluent -6	30	30	120	41	18	1.4	.04	.7	11	7.9
-9	10	L5	120	53	30	2.5	L.02	.5	7	8.2
-12	L15	L15	120	39	20	2.2	.03	.4	13	8.6
-15	L30	L30	120	4[illegible]	6	2.8	.02	.4	12	8.0
Virgin carbon effl.-6	9	8	61	36	16	L1	.02	.2	25	8.0
-9	8	5	73	25	52	2.5	L.02	.7	12	8.2
-12	4	3	80	23	24	3.4	L.02	.1	16	8.3
-15	6	L6	88	34	8	2.5	.02	.3	8	7.7
Reg.carbon effluent -6	11	10			24		L.02	.3	25	7.8
-9	8	5	77	28	24	2.5	L.02	.4	6	8.2
-12	3	3	88	29	24	2.8	L.02	.1	16	8.5
-15	7	L6	88	34	6	12	.02	.3	8	
Refinery P										
Filter influent -6	8	4	85	22	23	5.9	L.02	L.1	36	7.2
-9	8	4	100	54	16	7.0	L.02	L.1	5	7.4
-12	27	23	120	37	11	10	L.02	.3	40	7.3
Filter effluent -6	5	4	110	20	11	5.3	L.02	L.1	20	7.1
-9	8	9	160	70	21	7.0	L.02	L.1	4	7.3
-12	30	23	110	44	11	13	L.02	.4	26	6.8
Virgin carbon effl.-6	4	4	69	16	13	5.3	L.02	L.1	14	7.3
-9	4	L5	81	52	7	7.0	L.02	L.1	5	7.3
-12	24	23	56	25	4	9.5	L.02	L.1	20	7.1
Reg.carbon effl.-6	4	5	28	14	11	5.3	L.02	L.1	20	7.3
-9	2	L5	81	70	7	6.4	L.02	L.1	4	7.4
-12	14	6	68	19	4	11	L.02	L.1	1[illegible]	7.2

TABLE VI-11

ANALYTICAL RESULTS FOR RSKERL
GRANULAR ACTIVATED CARBON STUDY, PRIORITY POLLUTANTS

Sample - Day	Concentration (mg/l)		
	Cyanides	Phenolics	Mercury
Refinery B			
Filter influent - 6	L.02	.024	
Filter influent - 9	.01	.024	
Filter influent - 15	.12	.012	
Filter influent - Comp.			L.0005
Filter effluent - 6	.02	.022	
Filter effluent - 9	.01		
Filter effluent - 15	.12		
Filter effluent - Comp.			L.0005
Virgin carbon effluent - 6	L.02	L.01	
Virgin carbon effluent - 9	.01		
Virgin carbon effluent - 15	.01		
Virgin carbon effluent - Comp.			L.0005
Reg. carbon effluent - 6	L.02	L.01	
Reg. carbon effluent - 9	.01		
Reg. carbon effluent - 15	.04		
Reg. carbon effluent - Comp.			L.0005
Refinery H			
Filter influent - 6	L.02	.017	
Filter influent - 9	L.02	.019	
Filter influent - 15	L.02	.014	
Filter influent - Comp.			L.0005
Filter effluent - 6	L.02	[a]	
Filter effluent - 9	L.02		
Filter effluent - 15	L.02		
Filter effluent - Comp.			L.0005
Virgin carbon effluent - 6	L.02	[a]	
Virgin carbon effluent - 9	L.02		
Virgin carbon effluent - 15	L.02		
Virgin carbon effluent - Comp.			L.0005
Reg. carbon effluent - 6	L.02	[a]	
Reg. carbon effluent - 9	L.02		
Reg. carbon effluent - 15	L.02		
Reg. carbon effluent - Comp.			L.0005

[a] Samples were not analyzed because filter influent contained lower limits of detection.

TABLE VI-11 (Continued)

	Concentration (mg/l)		
Sample - Day	Cyanides	Phenolics	Mercury
Refinery K			
Filter influent - 6	L.02	.027	
Filter influent - 9		.018	
Filter influent - 12	L.02	.018	
Filter influent - 15	L.02	.031	
Filter influent - Comp.			.0008
Filter effluent - 6	L.02	.029	
Filter effluent - 9		.017	
Filter effluent - 12		.018	
Filter effluent - 15	L.02	.029	
Filter effluent - Comp.			L.0005
Virgin carbon effluent - 6	L.02	L.012	
Virgin carbon effluent - 9		L.012	
Virgin carbon effluent - 12		L.012	
Virgin carbon effluent - 15	L.02	L.01	
Virgin carbon effluent - Comp.			.0013
Reg. carbon effluent - 6	L.02	L.012	
Reg. carbon effluent - 9		L.012	
Reg. carbon effluent - 12		L.012	
Reg. carbon effluent - 15	L.02	L.01	
Reg. carbon effluent - Comp.			.0016
Refinery M			
Filter influent - 6	L.02	L.012	
Filter influent - 9	L.02		
Filter influent - 12	L.02	L.012	
Filter influent - 15	.10	L.010	
Filter influent - Comp.			.0008
Filter effluent - 6	.04	L.012	
Filter effluent - 9	L.02		
Filter effluent - 12	L.02		
Filter effluent - 15	.09		
Filter effluent - Comp.			L.0005
Virgin carbon effluent - 6	L.02	L.012	
Virgin carbon effluent - 9			
Virgin carbon effluent - 12			
Virgin carbon effluent - 15	.03		
Virgin carbon effluent - Comp.			L.0005
Reg. carbon effluent - 6	L.02	L.012	
Reg. carbon effluent - 9			
Reg. carbon effluent - 12			
Reg. carbon effluent - 15	.02		
Reg. carbon effluent - Comp.			L.0005

TABLE VI-11 (Continued)

	Concentration (mg/l)		
Sample - Day	Cyanides	Phenolics	Mercury
Refinery O			
Filter influent - 6	L.02	.038	
Filter influent - 9	L.02	.029	
Filter influent - 12	L.02	.025	
Filter influent - 15	L.02	.022	
Filter influent - Comp.			L.0005
Filter effluent - 6	L.02	.039	
Filter effluent - 9	L.02	.028	
Filter effluent - 12	L.02	.023	
Filter effluent - 15	L.02	.040	
Filter effluent - Comp.			L.0005
Virgin carbon effluent - 6	L.02	.005	
Virgin carbon effluent - 9	L.02	L.005	
Virgin carbon effluent - 12	L.02	L.005	
Virgin carbon effluent - 15	L.02	L.005	
Virgin carbon effluent - Comp.			L.0005
Reg. carbon effluent - 6	L.02	L.005	
Reg. carbon effluent - 9	L.02	L.005	
Reg. carbon effluent - 12	L.02	.005	
Reg. carbon effluent - 15	L.02	.007	
Reg. carbon effluent - Comp.			L.0005
Refinery P			
Filter influent - 6	.05	.013	
Filter influent - 9	.04	.028	
Filter influent - 12	.04	.058	
Filter influent - 15	.05	.090	
Filter influent - Comp.			L.0005
Filter effluent - 6	.05	.013	
Filter effluent - 9	.04	.016	
Filter effluent - 12	.04	.084	
Filter effluent - 15	.04	.092	
Filter effluent - Comp.			L.0005
Virgin carbon effluent - 6	.05	L.005	
Virgin carbon effluent - 9	.05	L.005	
Virgin carbon effluent - 12	.05	L.005	
Virgin carbon effluent - 15	.07	.005	
Virgin carbon effluent - Comp.			L.0005
Reg. carbon effluent - 6	.04	L.005	
Reg. carbon effluent - 9	.04	L.005	
Reg. carbon effluent - 12	.05	L.005	
Reg. carbon effluent - 15	.07	L.005	
Reg. carbon effluent - Comp.			L.0005

TABLE VI-11 (Continued)

		Concentration (µg/l)											
Sample	Lab	Ag	Be	Cd	Cr	Cu	Ni	Pb	Zn	As	Sb	Se	Tl
Refinery B*													
Filter influent	1	L1	2	5	50	16	L5	L20	L60	L20	L25	62	L15
	2	L5	L3	L1	23	L5	L15	L15	25				
Filter effluent	1	L1	2	L2	40	L6	L5	L20	70	L20	L25	56	L15
	2	L5	L3	L1	21	L5	L15	L15	60				
Virgin carbon effluent	1	L1	2	L2	30	L6	L5	L20	L60	L20	L25	50	L15
	2	L5	L3	L1	10	L5	L15	L15	35				
Reg. carbon effluent	1	L1	2	L2	30	9	L5	L20	L60	L20	L25	50	L15
	2	L5	L3	L1	5	L5	L15	L15	25				
Refinery H*													
Filter influent	1	L1	L1	10	10	10	L5	20	L60	L20	L25	L20	L15
	2	L5	L3	L1	L5	32	L15	L15	15				
Filter effluent	1	L1	L1	L2	9	10	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	L1	L5	14	L15	26	20				
Virgin carbon effluent	1	L1	L1	L2	L5	L6	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	L1	L5	L5	L15	L15	20				
Reg. carbon effluent	1	L1	L1	L2	10	7	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	L1	L5	L5	L15	L15	20				
Refinery K*													
Filter influent	1	L1	L1	L2	200	30	L5	L20	200	L20	L25	L20	L15
	2	L5	L3	L1	196	26	L15	L15	210				
Filter effluent	1	L1	L1	L2	40	10	L5	L20	100	L20	L25	L20	L15
	2	L5	L3	L1	28	L5	L15	L15	85				
Virgin carbon effluent	1	L1	L1	L2	10	L6	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	L1	10	L5	L15	L15	30				
Reg. carbon effluent	1	L1	L1	L2	20	L6	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	L1	10	L5	L15	L15	35				
Refinery M*													
Filter influent	1	5	L1	7	100	20	8	60	100	L20	L25	25	L15
	2	L5	L3	L1	24	L5	L15	L15	85				
Filter effluent	1	5	L1	L2	80	10	9	30	300	L20	L25	26	L15
	2	L5	L3	L1	17	L5	L15	L15	110				
Virgin carbon effluent	1	10	L1	L2	50	10	50	70	100	L20	L25	26	L15
	2	L5	L3	L1	8	L5	L15	L15	100				
Reg. carbon effluent	1	7	L1	L2	60	10	30	50	100	L20	L25	23	L15
	2	L5	L3	L1	10	L5	L15	L15	100				
Refinery O*													
Filter influent	1	L1	L1	L2	30	L6	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	L1	110	13	L15	L15	L10				
Filter effluent	1	L1	L1	L2	20	L6	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	L1	100	9	L15	L15	L10				
Virgin carbon effluent	1	L1	L1	L2	L5	L6	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	1	70	18	L15	L15	17				
Reg. carbon effluent	1	L1	L1	L2	60	L6	L5	L20	L60	L20	L25	L20	L15
	2	L5	L3	6	80	14	L15	L15	12				
Refinery P*													
Filter influent	1	L1	L1	L2	L5	L6	L5	L20	L60	L20	470	L20	L15
	2	L5	L3	1	60	13	16	L15	17				
Filter effluent	1	L1	L1	L2	L5	L6	L5	L20	L60	L20	430	L20	L15
	2	L5	L3	1	50	11	16	L15	30				
Virgin carbon effluent	1	L1	L1	L2	L5	L6	L5	L20	L60	L20	450	L20	L15
	2	L5	L3	4	46	20	42	L15	27				
Reg. carbon effluent	1	L1	L1	L2	L5	L6	L5	L20	L60	L20	410	L20	L15
	2	L5	L3	1	40	20	L15	L15	30				

LABS: 1 - EPA Region V
2 - RSKERL

NOTES: L - Less than
* - The 24-hour composites were composited into one sample for analysis.

TABLE VI-12
ANALYTICAL RESULTS
FOR
RSKERL POWDERED ACTIVATED CARBON STUDY, TRADITIONAL POLLUTANTS

Sample - Day	Concentration (mg/l)									
	BOD-1	BOD-3	COD	TOC	TSS	NH_3	Cr^{+6}	S^{-2}	O&G	pH
Refinery B										
Pilot plant influent-6	170	160	480	160	22	7.8	.09	.7	24	8.9
-9	110	110	350	58	28	3.9	.05	3.1	38	9.3
-12	110	110	400	98	36	6.7	L.02	2.6	23	8.4
-15	160	220	450	120	56	3.9	.06	1.8	16	9.2
Pilot plant effluent-6	L6	L6	63	28	30	20	L.02	.8	6	8.2
-9	L12	L12	100	20	42	15	L.02	2.7	5	7.8
-12	L12	L12	120	32	58	22	L.02	.7	14	7.8
-15	L12	L12	130	39	94	16	L.02	.8	12	7.8
Refinery K										
Pilot plant influent-6	110		1400	450	860	6.2	.11	2.7	240	7.3
-9	80		480	110	150	5.6	.02	1.8	470	7.1
-12	L60		840	200	280	10	.02	2.5	98	7.4
Pilot plant effluent-6	L6		76	29	30	2.2	L.02	.7	10	7.7
-9	L12		36	12	6	3.4	L.02	.6	11	7.5
-12	L12		48	19	14	2.0	L.02	.7	13	7.5
Refinery M										
Pilot plant influent-6	95		280	78	22	19	L.02	5.7	19	8.7
-9	63		360	87	32	20	L.02	1.0		8.3
-12	16		260	66	24	16	L.02	1.3	36	8.8
Pilot plant effluent-6	8		84	17	58	10	L.02	.7	28	5.6
-9	13		95	21	35	15	L.02	.5	12	5.8
-12	L12		140	32	62	11	L.02	.7	9	5.8
Refinery P										
Pilot plant influent-6	180	160	340	90	68	8.1	L.02	5.5	25	8.2
-9	130	110	460	160	78	10	L.02	7.6	80	8.2
-12	200	170			40		L.02	11	81	8.3
Pilot plant effluent-6	14	6	140	28	140	3.6	.02	2.3	20	7.0
-9	5	6	190	45	58	4.2	L.02	1.7	11	7.7
-12	10	16	150	56	50	13	L.02	1.0	26	7.6

TABLE VI-13

ANALYTICAL RESULTS FOR RSKERL
POWDERED ACTIVATED CARBON STUDY, PRIORITY POLLUTANTS

Sample - Day	Concentration (mg/l)		
	Cyanides	Phenolics	Mercury
Refinery B			
Pilot plant influent - 6	.05	24	
Pilot plant influent - 9	.06	18	
Pilot plant influent - 15	.07	31	
Pilot plant influent - Comp.			L.0005
Pilot plant effluent - 6	L.02	L.010	
Pilot plant effluent - 9	L.03	L.010	
Pilot plant effluent - 15	L.02	L.010	
Pilot plant effluent - Comp.			L.0005
Refinery K			
Pilot plant influent - 6	.01	.23	
Pilot plant influent - 9		3.8	
Pilot plant influent - 12	L.02	.95	
Pilot plant influent - 15	.02	.53	
Pilot plant influent - Comp.			L.0005
Pilot plant effluent - 6	L.02	L.012	
Pilot plant effluent - 9		L.012	
Pilot plant effluent - 12		L.012	
Pilot plant effluent - 15	L.02	.014	
Pilot plant effluent - Comp.			.0006
Refinery M			
Pilot plant influent - 6	.01	6.0	
Pilot plant influent - 9		6.4	
Pilot plant influent - 12	.02	6.2	
Pilot plant influent - 15	.28	5.2	
Pilot plant influent - Comp.			L.0005
Pilot plant effluent - 6	L.02	L.012	
Pilot plant effluent - 9		L.012	
Pilot plant effluent - 12		.018	
Pilot plant effluent - 15	.07	L.010	
Pilot plant effluent - Comp.			L.0005
Refinery P			
Pilot plant influent - 6	.05	39	
Pilot plant influent - 9	.06	42	
Pilot plant influent - 12	.05	80	
Pilot plant influent - 15	.01	58	
Pilot plant influent - Comp.			L.0005
Pilot plant effluent - 6	.02	.065	
Pilot plant effluent - 9	L.02	.039	
Pilot plant effluent - 12	L.02	.099	
Pilot plant effluent - 15	.02	.027	
Pilot plant effluent - Comp.			L.0005

TABLE VI-13 (Continued)

		Concentration (µg/l)											
Sample	**Lab**	**Ag**	**Be**	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**As**	**Sb**	**Se**	**Tl**
Refinery B*													
Pilot plant influent	1	L1	L1	L2	100	L6	L5	L20	L60				
	2	L5	L3	L1	81	L5	L15	L15	30	L20	L25	L20	L15
Pilot plant effluent	1	L1	L1	L2	30	L6	L5	L20	L60				
	2	L5	L3	L1	18	L5	15	L15	30	L20	L25	40	L15
Refinery K*													
Pilot plant influent	1	L1	2	L2	2000	400	20	100	10000				
	2	L5	L3	3	1700	370	27	65	1800	L20	L25	L20	L15
Pilot plant effluent	1	L1	L1	L2	70	20	L5	L20	100				
	2	L5	L3	L1	49	8	L15	L15	120	L20	L25	L20	L15
Refinery M*													
Pilot plant influent	1	2	2	L2	500	20	10	L20	300				
	2	L5	L3	L1	393	17	L15	L15	250	L20	L25	23	L15
Pilot plant effluent	1	L1	2	20	60	9	L5	60	100				
	2	L5	L3	L1	33	L5	L15	L15	170	L20	L25	L20	L15
Refinery P													
Pilot plant influent	1	L1	L1	L2	700	L6	L5	L20	100				
	2	L5	L3	7	620	14	16	L15	110	L20	430	L20	L15
Pilot plant effluent	1	L1	L1	L2	70	L6	L5	L20	70				
	2	L5	L3	6	110	52	39	L15	85	L20	410	L20	L15

LABS: 1 - EPA Region V
2 - RSKERL

NOTES: L - Less than
* - The 24-hour composites were composited into one sample for analysis.

TABLE VI-14

Zero Discharge Refineries*

Refinery	Capacity (1000 bbl/stream day)	Wastewater Disposition
C&H Refinery, Inc. Lusk, WY	.05	Evap/perc pond
Southwestern Refining Co., Inc. LaBarge, WY	.5	No wastewater generated
United Independent Oil Co. Tacoma, WA	.75	No wastewater generated
Yetter Oil Co. Colmer, IL	1.	Evap/perc pond
Dorchester Gas Producing Co. Amarillo, TX	1.	Evap/perc pond
Mountaineer Refining Co., Inc. LaBarge, WY	1.	Evap/perc pond
Glenrock Refinery, Inc. Glenrock, WY	1.	Evap/perc pond
Thriftway, Inc. Graham, TX	1.	No wastewater generated
Sage Creek Refining Co. Cowley, WY	1.	No wastewater generated
Pioneer Refining, Ltd. Nixon, TX	2.2	Evap/perc pond
Oxnard Refinery Oxnard, CA	2.5	Disposal well
Caribou Four Corners, Inc. Kirtland, NM	2.5	No wastewater generated
Kenco Refinery, Inc. Wolf Point, MT	3.	Evap/perc pond
Kentucky Oil and Refining Co. Betsy Layne, Ky	3.0	No wastewater generated

* This table includes all refineries whose production wastewater (excluding stormwater, ballast water, once-thru non-contact cooling water, and sanitary wastewater) is not discharged directly via an NPDES permit nor is discharged to a POTW. This table also includes those refineries which do not generate production wastewater.

TABLE VI-14 (Continued)

Refinery	Capacity (1000 bbl/stream day)	Wastewater Disposition
Sabre Refining, Inc. Bakersfield, CA	3.5	Contract disposal
Mid-Tex Refinery Hearne, TX	3.5	Recycle (7/1/77)
Bayou State Oil Corp. Shreveport, LA	4.	Disposal well, Evap/perc pond
Thriftway Co. Farmington, NM	4.	Evap/perc pond
Southern Union Refining Co., Monument Refinery, Hobbs, NM	4.5	Disposal well
Arizona Fuels Corp. Fredonia, AZ	5.	Leaching bed Disposal well
Tonkawa Refining Co. Arnett, OK	5.	Evap/perc pond
Plateau, Inc. Roosevelt, UT	5.6	Evap/perc pond
Texas Asphalt and Refining Co. Euless, TX	6.0	Evap/perc pond Contract disposal
Sunland Refining Corp. Bakersfield, CA	7.	Evap/perc pond
Plateau, Inc. Farmington, NM	7.5	Evap/perc pond
Douglas Oil Co. of CA Santa Maria, CA	9.5	Disposal well
Gary Western Co. Fruita, CO	10.	Evap/perc pond Recycle
E-Z Serve, Inc. Scott City, KS	10.	Evap/perc pond
Husky Oil Co. Cody, WY	10.8	Evap/perc pond (7/1/77)

TABLE VI-14 (Continued)

Refinery	Capacity (1000 bbl/stream day)	Wastewater Disposition
Witco Chemical Corp. Oildale, CA	11.	Contract disposal
Newhall Refining Co., Inc. Newhall, CA	12.	Contract disposal
Atlantic Richfield Co. Prudhoe Bay, AK	13.	Evaporation
Atlantic Terminal Corp. Newington, NH	15.	Leaching bed
Kern County Refinery, Inc. Bakersfield, CA	17.	Surface spray
San Joaquin Refining Co. Bakersfield, CA	17.	Evap/perc pond, recycle
Texaco Inc. El Paso, TX	17.	Evap/perc pond, recycle
Shell Oil Co. Gallup, NM	19.	Evap/perc pond
Texaco, Inc. Amarillo, TX	20.	Disposal well, Evap/perc pond
Texaco, Inc. Casper, WY	21.	Evap/perc pond, recycle
Mohawk Petroleum Corp., Inc. Bakersfield, CA	22.8	Evap/perc pond
CRA, Inc. Phillipsburg, KS	23.2	Evap/perc pond
Husky Oil Co. Cheyenne, WY	24.2	Evap/perc pond
Southern Union Refining Co. Lovington Refinery, Hobbs, NM	25.1	Disposal well
Little America Refining Co. Evansville, WY	25.5	Evap/perc pond
Chevron U.S.A. Inc. Bakersfield, CA	26.	Contract disposal, recycle

TABLE VI-14 (Continued)

Refinery	Capacity (1000 bbl/stream day)	Wastewater Disposition
Navajo Refining Co. Artesia, NM	29.9	Evap/perc pond
Champlin Petroleum Co. Wilmington, CA	32.	Disposal well
Shell Oil Co. Odessa, TX	35.	Evap/perc pond
Lion Oil Co. Bakersfield, CA	40.	Disposal well, Evap/perc pond
Amoco Oil Co. Casper, WY	44.5	Evap/perc pond, recycle
Sinclair Oil Corp. Sinclair, WY	50.9	Evap/perc pond
Diamond Shamrock Corp. Sunray, TX	53.5	Disposal well
Cosden Oil and Chemical Co. Big Spring, TX	56.	Evap/perc pond, recycle
Hawaiian Independent Refininery Ewa Beach, HI	60.3	Disposal well, Evap/perc pond
Chevron U.S.A. Inc. El Paso, TX	75.	Evap/perc pond

TABLE VI-15

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
001	DAP Act. Sludge	Corr. Plate Sep. DAF Act. Sludge	0.61	1.07	-207
002		Chemical Floc.	0.291	0.186	36
003		RBC		0.125	
004		None			
006	Stab. Pond	DAF Aerated Lag.	0.144	0.144	0.0
007	DAF Stab. Pond	DAF Aerated Lag.	0.200	0.243	-22
008	Aerated Lag.			10.0	
009	Aerated Lag.	Aerated Lag. Pol. Pond	0.26	0.09	65
010	Stab. Pond	Stab. Pond	0.44	0.14	68
011	Stab. Pond		2.92	3.52	-21
012	Stab. Pond	Pre-Filtration Stab. Pond	0.23	0.72	-213
013	DAF	Chemical Floc. DAF	12.35	10.96	11
014	DAF		0.062	0.155	-150
015	DAF Filtration	Chemical Floc. OAF		0.270	
016	None	None		0.56	
017		Chemical Floc. Evap. or Perc. Pond		0.06	
018	None	None		0.69	
019	None	None			
020	DAF Act. Sludge	Chemical Floc. DAF Act. Sludge Pol. Pond	4.79	4.51	5.8
021	None	None		0.22	
022		DAF		0.18	
023		Filtration Evap. or Perc. Pond		.475	
024	DAF Aerated Lag.	DAF Aerated Lag. Other Org. Rem.	0.35	0.54	-54
025	DAF	DAF Other Org. Rem.		1.4	
026	None	Other Org. Rem.		0.35	
027					

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
028					
029	None	OAF		6.5	
030	None	Evap. or Perc. Pond		0.33	
031	None	DAF		0.10	
032	DAF Aerated Lag. Stab. Pond	DAF Aerated Lag. Stab. Pond	18.80	16.2	14
033			0.71		
034					
035		None		4.0	
036	Evap. or Perc. Pond	Evap. or Perc. Pond		0.12	
037	DAF Act. Sludge	DAF Aerated Lag. Pol. Pond	7.6	7.6	0.0
038	Corr. Plate Sep. DAF	Corr Plate Sep. DAF	7.73	6.34	18
039	Evap. or Perc. Pond			0.35	
040	None	Chemical Floc. DAF Act. Sludge Others Org. Rem.	57.0	41.2	20
041	Aerated Lag.	Corr. Plate Sep. Aerated Lag. Stab. Pond Pol. Pond		126.2	
042	Aerated Lag. Evap. or Perc. Pond	Chemical Floc. Aerated Lag. Evap. or Perc. Pond		0.10	
043	None	DAF Stab. Pond		4.96	
044		Filtration Evap. or Perc. Pond		2.72	
045	DAF	Chemical Floc. DAF OAF	29.71	28.9	2.7
046	DAF	Chemical Floc. DAF	55.60	44.	21
047					
048	Stab. Pond Evap. or Perc. Pond	Evap. or Perc. Pond	1.27	0.85	33
049	Aerated Lag.	Aerated Lag. Pol. Pond	1.53	0.77	50
050	Aerated Lag.	DAF Aerated Lag. Stab. Pond Filtration	0.40	0.47	-18
051	Act. Sludge	Chemical Floc. DAF Act. Sludge Pol. Pond		321.	
052	Evap. or Perc. Pond	Stab. Pond Pol. Pond		0.34	
053	None	Filtration	1.25	0.11	Questionable Data

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
054	DAP		0.08	0.09	-13
055	None	Corr. Plate Sep. Stab. Pond Pol. Pond Evap. or Perc. Pond		0.18	
056	Aerated Lag.	DAF Aerated Lag. Pol. Pond Evap. or Perc. Pond	4.24	5.82	-37
057	Aerated Lag.	Aerated Lag. Pol. Pond		17.63	
058	None	DAF		2.73	
059	DAF Aerated Lag.	DAF Act. Sludge	51.27	2.4	Questionable Data
060	DAF Aerated Lag. Act. Sludge Filtration	Chemical Floc. DAF Act. Sludge Filtration	4.84	5.2	-7.4
061	DAF Act. Sludge	Chemical Floc. DAF Act. Sludge Pol. Pond	12.09		
062	Trick. Filter Evap. or Perc. Pond	Trick. Filter Aerated Lag. Pol. Pond	13.4	9.57	29
063	Aerated Lag. Stab. Pond	Aerated Lag. Pol. Pond	7.97	8.79	-10
064	DAF Act. Sludge	DAF Act. Sludge	27.89	24.8	11
065	Act. Sludge	Act. Sludge Pol. Pond	4.06	5.0	-23
066		Evap. or Perc. Pond		0.001	
067	DAF Aerated Lag.	Chemical Floc. DAF Aerated Lag.	13.49	144.3	-7
068	Act. Sludge	Act. Sludge	8.52	6.72	21
070		None		0.17	
071	DAF Stab. Pond	Chemical Floc. DAF Aerated Lag. Pol. Pond	0.68	0.59	13
072	Aerated Lag. Stab. Pond	Chemical Floc. Aerated Lag. Pol. Pond	1.44		
073	Aerated Lag. Stab. Pond	Chemical Floc. Aerated Lag. Pol. Pond	1.01	1.79	-77
074	Aerated Lag.	Aerated Lag. Pol. Pond	0.63	0.67	-6.3
075	None		1.27		
076	Stab. Pond	Chemical Floc. Aerated Lag. Pol. Pond	3.60	3.0	17
077	Evap. or Perc. Pond	Act. Sludge Pol. Pond Evap. or Perc. Pond	0.63	0.63	0.0
078	None	Chemical Floc.		0.51	
079	None		0.16		
080	Stab. Pond	Stab. Pond	1.33	3.46	-160

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
081	Chemical Floc. Aerated Lag. Stab. Pond	Aerated Lag. Pol. Pond	2.50	1.58	37
082	None	Evap. or Perc. Pond			
083	DAF	DAF	4.63	4.86	-5.0
084	Aerated Lag. Stab. Pond	DAF Act. Sludge Pol. Pond	3.54	3.84	-8.5
085	None	Chemical Floc. OAF Act. Sludge	11.0	10.43	5.2
086	DAF	Chemical Floc. DAF	0.35	0.47	- 4
087	None	Evap. or Perc. Pond	0.42	1.0	-130
088	OAF	Stab. Pond		1.16	
089	Evap. or Perc. Pond	Evap. or Perc. Pond	0.31	0.19	39
090		Aerated Lag.		0.031	
091	None	None	0.032	0.012	63
092	DAF Other Org. Rem.	DAF Act. Sludge Aerated Lag. Pol. Pond	321.5	270.8	13
093		None			

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
094	Act. Sludge Aerated Lag.	Corr. Plate Sep. DAF Act. Sludge Pol. Pond	4.59	3.6	22
095	None	Stab. Pond Pol. Pond	0.60		
096	Corr. Plate Sep. Aerated Lag.	Corr Plate Sep. Chemical Floc. DAF Act. Sludge	90.52	34.64	62
097		None		0.034	
098	Aerated Lag.	OAF DAF Aerated Lag. Stab Pond	31.27	26.56	15
099		DAF Aerated Lag. Pol. Pond		121.	
100	Filtration	Filtration		0.19	
101	Aerated Lag.				
102	Aerated Lag.	Aerated Lag.	17.9	21.1	-18
103		Aerated Lag.		0.27	
104	Aerated Lag.	Corr. Plate Sep. Aerated Lag. Stab. Pond	24.88	21.34	14
105	Aerated Lag.	Chemical Floc. OAF Aerated Lag.	71.0	84.	-18
106	Stab. Pond	Aerated Lag. Pol. Pond.	5.76	4.59	20

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
107	None	Filtration	0.39	0.39	0.0
108	DAF	OAF	0.31	0.34	-9.7
109	DAF Act. Sludge Trick. Filter	Chemical Floc. DAF Act. Sludge Trick. Filter Pol. Pond	83.25	66.22	20
110	Stab. Pond		1.22	1.0	18
111		Chemical Floc. DAF		1.0	
112	Filtration	Aerated Lag.	0.75	0.51	32
113	Aerated Lag.	Aerated Lag. Pol. Pond	1.14	0.90	21
114	Aerated Lag.	Aerated Lag. Pol. Pond	0.72	0.59	18
115	Act. Sludge	Pre-Filtration Act. Sludge Pol. Pond	5.05	3.92	22
116	Aerated Lag.	Stab. Pond	2.06	2.77	-34
117	DAF Aerated Lag. Stab. Pond	OAF Aerated Lag. Pol. Pond	2.01	2.10	-4.5
118	None	Aerated Lag. Filtration	0.13	0.94	-623
119	Filtration	Aerated Lag. Filtration	0.17	0.23	-35
120	None	Aerated Lag. Filtration	0.35	0.29	17
121	Corr. Plate Sep. DAF Aerated Lag. Stab. Pond	Corr. Plate Sep. DAF Aerated Lag. Other Org. Rem Pol. Pond	34.5	14.0	59
122	Aerated Lag.	Aerated Lag.	12.00	35.	Questionable Data
124	None	Chemical Floc. DAF Stab. Pond		1.07	
125	Aerated Lag. Stab. Pond	Aerated Lag. Other Org. Rem. Pol. Pond	1.23	1.28	-4.1
126	Aerated Lag. Stab. Pond	Aerated Lag. Pol. Pond	33.0	40.8	-24
127	DAF Aerated Lag. Stab. Pond	Chemical Floc. DAF Aerated Lag. Pol. Pond	0.31	0.25	19
128		Evap. or Perc Pond		0.01	
129	Evap. or Perc. Pond	Aerated Lag. Evap. or Perc. Pond Pol. Pond		0.15	
130	None	None	3.13	2.67	15
131	Stab. Pond	OAF RBC	74.01	56.6	24
132	Act. Sludge Aerated Lag.	OAF Activated Sludge	174.5	181.5	-4.0
133	Stab. Pond	DAF Act. Sludge Trick. Filter Filtration	35.28	19.3	45
134	Stab. Pond	Act. Sludge Filtration	.64	.91	-2.0

TABLE VI 35 (Continued)

Treatment Operations and Water Usage: 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
135					
136		Corr. Plate Sep.		0.6	
137	None	None		0.06	
138	None	Evap. or Perc. Pond		1.03	
139	Stab. Pond	Evap. or Perc. Pond		0.168	
140		Evap. or Perc. Pond		0.5	
141	None	Evap. or Perc. Pond		0.03	
142	DAP	Chemical Floc. DAP	18.35	21.67	-18
143	DAP	Chemical Floc. DAP	28.85	33.7	-17
144	Aerated Lag.	Aerated Lag. Pol. Pond	45.02	1.77	Questionable Data
145		None		0.014	
146	Stab. Pond	Stab. Pond	0.32	0.3	6.3
147	DAP	Chemical Floc. DAP Act. Sludge	1.40	1.94	-39
148	DAP	DAP		0.47	
149	Aerated Lag.	Corr. Plate Sep. Aerated Lag.	1.78	4.92	-176
150	Aerated Lag.	Corr. Plate Sep. Act. Sludge	84.44	[illegible]0.14	29
151	DAP Aerated Lag.	Chemical Floc. DAP Aerated Lag. Pol. Pond	6.50	7.59	-17
152	DAP Aerated Lag.	DAP Act. Sludge	122.1	44.05	64
153	Act. Sludge Trick. Filter Aerated Lag. Stab. Pond	Other Organics Rem. Filtration	5.43	4.7	13
154	Aerated Lag.	Stab. Pond Pol. Pond	0.31	0.85	-174
155	Stab. Pond	Stab. Pond Pol. Pond	0.59	0.65	-10
156	Aerated Lag.	Chemical Floc. DAP Aerated Lag. Pol. Pond	2.47	2.37	4.0
157	Other Organics Rem.	Act. Sludge Aerated Lag. Other Organics Rem.	7.65	7.33	4.2
158	Act. Sludge Stab. Pond	Act. Sludge Pol. Pond	1.40	1.49	-6.4
159	None	Stab. Pond Pol. Pond	0.75	0.69	8.0
160	DAP Act. Sludge Filtration	Checical Floc. OAP Act. Sludge Stab. Pond Pol. Pond Evap. or Perc. Pond	0.53	0.65	-23

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.	Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
161	Aerated Lag.	Aerated Lag. Other Organics Rem. Pol. Pond	1.72	3.12	-81	175	None	Corr. Plate Sep.	124.5	106.6	14
162	DAF Aerated Lag.	DAF Act. Sludge	5.84	6.3	-7.9	176	None	Aerated Lag.	3.28	5.86	-79
163	Aerated Lag.	Aerated Lag. Pol. Pond	4.48	3.5	22	177	None	None	4.10	2.15	48
164		Evap. or Perc. Pond				178	DAF		0.82		
165	Stab. Pond	Chemical Floc. DAF Stab. Pond Pol. Pond	0.73	0.80	-9.6	179	Aerated Lag.	Chemical Floc. Aerated Lag. Stab. Pond Pol. Pond	0.98	0.98	0.0
166	None	None		0.2		180	Aerated Lag. Evap. or Perc. Pond	DAF Act. Sludge	4.38	3.91	11
167	DAF Other Organics Rem.	Chemical Floc. DAF Act. Sludge	9.84	11.8	-20	181	Aerated Lag.	Pre-Filtration Act. Sludge Filtration	26.70	27.5	-3.0
168	Filtration Act. Carbon	Pre-Filtration Act. Carbon	81.4	123.	-51	182	Aerated Lag.	Act. Sludge	16.56	14.53	12
169	Act. Sludge Trick. Filter	Act. Sludge Trick. Filter	51.2	49.23	3.8	183	DAF Aerated Lag.	Chemical Floc. DAF Aerated Lag. Pol. Pond	1.00		
170	None		7.84			184	Act. Sludge	Chemical Floc. Act. Sludge	6.32	6.60	-4.5
172	None	None		1.58		185	Evap. or Perc. Pond	Evap. or Perc. Pond		2.4	
173	None	None	5.43	3.07	43	186	DAF Act. Sludge	DAF Act. Sludge Stab. Pond	4.35	5.13	-18
174	None	Aerated Lag.	20.8	8.08	72	187	Evap. or Perc. Pond	Filtration Evap. or Perc. Pond		2.35	

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
188	None	Corr. Plate Sep.	6.22	5.23	16
189	None	Aerated Lag. Pol. Pond	0.05	0.03	40
190	DAF Aerated Lag.	Aerated Lag. Pol. Pond	0.40	0.12	70
191	DAF			2.89	
192		Evap. or Perc. Pond		0.035	
193	None	None	0.039	0.053	-36
194	Aerated Lag. Stab. Pond	Aerated Lag. Pol. Pond	44.25	32.7	26
195	None	None		0.0011	
196	DAF Act. Sludge Stab. Pond	Corr. Plated Sep. Chemical Floc. DAF Act. Sludge Stab. Pond	130.0	46.38	64
197		Aerated Lag. Pol. Pond		0.012	
198	None				
199		Pre-Filtration Aerated Lag. Filtration		0.05	
200	None	None	2.00	1.43	29

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
201	DAF Aerated Lag.	Chemical Floc. DAF Act. Sludge Filtration	2.02	2.9	-44
202				0.004	
203	DAF Act. Sludge	Chemical Floc. DAF	52.4	29.14	44
204	Act. Sludge	Chemical Floc. DAF Act. Sludge Pol. Pond		6.07	
205	DAF Aerated Lag. Stab. Pond	DAF Aerated Lag. Pol. Pond	12.66	9.05	29
206	Evap. or Perc. Pond		0.05	0.14	-180
207	None	None			
208	Trick. Filter Act. Sludge Stab. Pond	Corr. Plate Sep. Act. Sludge Trick. Filter Stab. Pond	15.25	23.2	-52
209	Evap. or Perc. Pond	DAF Stab. Pond Pol. Pond Evap. or Perc. Pond		0.76	
210		None			
211	DAF Aerated Lag.	Chemical Floc. DAF Act. Sludge Aerated Lag. Filtration	1.25	1.98	-58
212	DAF Act. Sludge	DAF Act. Sludge	3.57		
213	DAF	DAF Aerated Lag. Stab. Pond Pol. Pond		0.14	

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
214	Evap. or Perc. Pond	Evap. or Perc. Pond			
215	Evap. or Perc. Pond	Evap. or Perc. Pond			
216	Act. Sludge Aerated Lag.	Chemical Floc. Act. Sludge Aerated Lag.	672.	53.24	Questionable Data
218	Evap. or Perc. Pond			0.60	
219	Aerated Lag.	Aerated Lag. Pol. Pond Filtration		3.45	
220	Evap. or Perc. Pond			0.087	
221	Act. Sludge	Other Organics Rem.	14.33	8.15	43
222	Stab. Pond	Aerated Lag. Pol. Pond		0.89	
223		None			
224	DAP	Chemical Floc. DAP	0.40	0.413	-3.3
225	DAP	DAP Filtration		2.52	
226	Stab. Pond	Stab. Pond Pol. Pond	0.04	0.084	-110
227	Stab. Pond Evap. or Perc. Pond	DAP Aerated Lag. RBC Pol. Pond Filtration	2.56	2.59	-1.2
228	Evap. or Perc. Pond	Stab. Pond Pol. Pond	0.48	0.55	-15
229	None	Evap. or Perc. Pond		0.15	
230	Stab. Pond	Stab. Pond	1.80	1.5	17
231					
232	Aerated Lag. Filtration	Chemical Floc. Filtration	72.22	63.65	12
233	DAP Act. Sludge Stab. Pond	Act. Sludge Trick. Filter Pol. Pond	5.59	3.75	33
234	DAP Act. Sludge	DAP Act. Sludge Trick. Filter Pol. Pond	2.30		
235	Trick. Filter Act. Sludge	Act. Sludge Trick. Filter Pol. Pond	4.40	3.66	17
236	Filtration		0.13	0.15	-15
237	Corr. Plate Sep.	Corr. Plate Sep. DAP Act. Carbon		0.038	
238	Trick. Filter Act. Sludge	Act. Sludge Trick. Filter Aerated Lag. Stab. Pond Pol. Pond	3.72	4.2	-13
239	Filtration Stab. Pond	Corr Plate Sep. RBC Pol. Pond	0.23	0.216	6.1

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
240	None		1.58	1.34	15
241	Other Organics Rem.	Act. Sludge Pol. Pond	2.47	0.96	61
242	None	None	0.95	0.86	9.5
243	Aerated Lag. Evap. or Perc. Pond	Aerated Lag. Pol. Pond	0.86	0.77	10
244		Evap. or Perc. Pond		3.19	
245	Stab. Pond	Corr. Plate Sep. Aerated Lag. Pol. Pond Evap. or Perc. Pond			
246	DAF Stab. Pond Evap. or Perc Pond	Aerated Lag. Evap. or Perc. Pond Pol. Pond	2.16	2.84	-31
247	Evap. or Perc. Pond	Evap. or Perc. Pond		0.84	
248		Evap. or Perc. Pond			
249	DAF Evap. or Perc. Pond	DAF Evap. or Perc Pond			
250	Evap. or Perc. Pond				
251					
252	Stab. Pond	Stab. Pond	0.24	0.32	-33

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
253	Evap. or Perc. Pond	Evap. or Perc. Pond			
254		None		1.0	
255		Pre-Filtration Aerated Lag. Pol. Pond		0.13	
256		Corr. Plate Sep. Stab. Pond		0.04	
257	DAF Aerated Lag.	Stab. Pond		99.5	
258	Aerated Lag.	DAF Act. Sludge Pol. Pond		1.96	
259		CAF Act. Sludge		21.55	
260	None	Aerated Lag.	0.25	1.0	-300
261		DAF Trick. Filter RBC Evap. or Perc. Pond			
264				3.0	
265		Corr. Plate Sep. DAF Act. Sludge Stab. Pond Pol. Pond		2.07	
266	None	None	0.94	0.83	12

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations 1973	Treatment Operations 1976	Water Usage Million Gal/Day 1973	Water Usage Million Gal/Day 1976	% Red.
275					
278		None		0.024	
282					
283					
284					
285					
288					
289					
290					
291					
292					
293					
294					
295					
296					
297					
298					
299					
300					
301					
302		Evap. or Perc. Pond			
303					
304					
305					
306					
307					

TABLE VI-15 (Continued)

Treatment Operations and Water Usage 1973 and 1976

Ref. No.	Treatment Operations		Water Usage Million Gal/Day		% Red.	Ref. No.	Treatment Operations		Water Usage Million Gal/Day		% Red.
	1973	1976	1973	1976			1973	1976	1973	1976	
308		Evap. or Perc. Pond									
309		Chemical Floc. Act. Sludge Aerated Lag.									

TABLE VI-16

Summary of Treatment Technologies
For 1973 and 1976

Treatment Systems	Number of Refineries 1973	 1976
Corrugated Plate Separators	4	20
Chemical Flocculation	1	46
Dissolved Air Flotation	56	68
Other Flotation Systems	1	15
Prefiltration	Unknown	6 (1)
Activated Sludge	30	50
Trickling Filter	7	10
Aerated Lagoon	63	73
Stabilization Pond	44	35
Rotating Biological Contactor	0	5
Other Organics Removal	4	10
Filtration	10	23 (1)
Polishing Ponds	Unknown	75
Activated Carbon	1	2
Evaporation or Percolation Ponds	26	37

(1) Two refineries have both prefiltration and post filtration, so that a total of only 27 refineries had filtration systems in 1976.

TABLE VI-17

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
3	-	1978	Upgrade piping and installing air coolers
7	0.115	1977	Stripping steam to crude unit
9	0.023	-	In plant modifications
11	0.72	1977	Better cooling tower controls and waste water supervision
12	0.0014	1977	Recycle
13	-	-	Cascading of sour water
18	0.0462	1977	Sour water stripper effluent to desalter or cooling towers (50-50)
22	0.021	1978	Recycle
31	0.050	-	Waste water to cooling tower
35	1.89	1977	Replace once-thru condensers with recycled water
39	-	-	Reuse
40	1.2	1978	Discontinue selected quench streams
42	5.0	-	Recycle
44	0.230	1979	Recycle cooling tower water and boiler blowdown
45	1.93	1977	Stripped sour water to desalter
46	0.450	1977	Stripped sour water to cooling towers and recycle cooling water and desalter water
50	0.052	1977	Sour water used for desalting
53	0.100	1978	Reuse and increase cooling water cycles
57	6.0	1977	Recycle cooling water and control blowdowns
59	0.11	1980	Water management within refinery

TABLE VI-17 (Continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
63	0.240	1977	Reroute cooling tower blowdown and new storm water handling facilities
64	2.37	1983	Closed system for pump cooling; eliminate once-thru cooling; cooling cycles increase via acid injection
67	-	-	Recycle and make-up for firewater
71	0.04	1977	Storm water segregation
72	0.020	1977	Larger cooling capacity for lower blowdown rates
74	-	1977	Improved condensate recovery
76	0.5	1978	Fin fan air condensing
77	-	1977	Runoff to be used as cooling tower make-up Stripped sour water used as desalter make-up
78	0.063	-	Treated sour water to desalter
82	-	1982	Switch to Fin fan cooling
87	0.00001	1977	Reuse of wastewater in gas handling system
88	0.16	1977	Non-refinery runoff eliminated
90	0.002	1978	Closed loop cooling loops and some recycle
92	0.270	1978	Cooling towers replacing once-thru cooling
96	2.1	1977	Treated wastewater for firewater system
102	0.417	-	Recycled treated wastewater
106	0.259	1977	Stormwater segregation
107	0.04	1977	Recycle wastewater effluent to cooling tower make-up
113	0.072	1977	Reduce once-thru cooling and tower blowdown

TABLE VI-17 (Continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
115	0.08	1978	Recycle process wastewater to coker cooling
117	0.200	1977	Pump gland cooling to cooling towers
122	0.700	1977	Coker recycle water system
132	0.7	1978	Uncontaminated stream segregation
138	0.538	-	Recycle to cooling towers
144	0.08	1977	Two series desalter
150	0.072	1978	Segregated once-thru pump gland cooling and plant wastewater conservation program
152	0.4	1978	Firewater use reduction and mechanical pump seal replacement
153	1.0	1977	Recycle treated wastewater to cooling towers
156	0.216	1977	Cooling tower cycle increases (blowdown decreases)
162	1.0	1977	Recycled wastewater to process units
163	0.166	1977	Segregation of uncontaminated runoff
169	1.55	1977	Reuse of process water
172	0.156	1977	Replacement of barometric condenser with surface condensers and treated sour water recycle to desalter
173	0.180	1977	Segregate uncontaminated runoff and replace barometric condenser with non-contact condensing system
181	3.0	1978	Reduce boiler blowdown via better control; Increase cooling tower cycles; Cascade boiler blowdown from high pressure boilers to low pressure boilers; Use boiler blowdown as desalter water; Use clarifier overflow and regeneration water

TABLE VI-17 (Continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
181 Cont'd.			from condensate polisher as cooling tower make-up; Recycle filter backwash to clarifier; Reuse coke cutting water and coke drum coolwater in delayed coking units; Reuse treated wastewater in firewater system
182	0.94	1977	Treated wastewater used as utility water and greater reuse of stripper bottoms
183	0.080	1977	Recycle desalters effluent
184	0.144	1978	Steam condensate collection & reuse
185	0.837	1981	Effluent reuse and solar evaporation
187	0.72	1977	Recycle effluent to cooling towers
191	0.140	1979	Sour water stripper
194	3.0	1977	Replacement of barometric condensers; Utilization of recycled fire waters in cat cracker; Cooling tower blowdown atomation
196	9.	1983	Recyle of wastewater to cooling tower and segregation of storm waters
200	0.022	1977	Stripped sour water to desalter
202	-	1977	Total recycle
207	0.0005	1977	Increase heat recovery at reformer to reduce cooling requirements
208	-	1980	Increase cooling tower cycles; Reuse of boiler blowdown; Recovery of condensate; Recycle demineralizing regenerants to fire system; reuse appropriate water as cooling water
210	0.003		Boiler blowdown and stripped sour water to be used in desalter

TABLE VI-17 (Continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
216	4.56	1977	Reuse of effluent, stormwater and sludge blowdown decant as intake and activated sludge effluent as service water intake
220	1.0	1977	Condensate from tower over heads to desalter feed
227	0.0432	1978	Sour water treatment to reduce volume requiring stripping
229	0.0125	1978	Strip ammonia from cat cracking condensate to release water for desalter
231	0.300	1977	Once-thru cooling to become cooling towers
232	-	-	Program being developed
236	0.026	1977	Contact cooling to non-contact cooling
240	0.37	1977	Contact cooling to non-contact cooling
242	0.36	1977	Non-contact cooling water segregation
247	0.652	-	Find market for spent phenolic caustic
249	14.4	1977	Reroute cooling tower blowdown to spray pond
252	0.016	1977	Additional wastewater evaporation
254	0.500	-	-
259	0.072	1977	Recycle boiler blowdown
265	0.537	-	Ballast water bottoms, desalter water, and zealite regeneration brine to disposal well
298	-	-	Install water softeners to reduce cooling tower blowdown

TABLE VI-17 (Continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
308	-	--	Study underway
309	0.15	1978	Replacement of two vacuum jet ejecters on solfolane unit with vacuum pumps.

TABLE VI-18

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
3	Steam stripper to be added
10	DAF unit to be installed
11	Sour waters to be stripped; Separator effluent to equalization, pH adjustment, flocculation, DAF, bio-reactors, clarification and filtering
15	API effluent to CPI and then to detention pond
16	DAF unit to be installed
25	API sludge handling system to be installed
32	Replace stabilization with bio-disc, and effluent to pass through clarifier carbon and filtration
37	DAF sludge thickener to be installed
38	Chemical floculation and DAF unit to be added
39	Final effluent to be used as boiler feed water
40	DAF effluent to equalization, activated sludge, and clarification
42	Detention pond effluent to oxidation pond, then percolation ponds;Clarifier effluent to filter before recycle to cooling tower
44	Desalter effluent to separate separators; Two CPI and sand filter at deep well; two stage sour water stripper; Warm lime treatment for boiler and cooling water; Equipment for SS removal or wet scrubbers blowdown
45	Tie in to POTW
46	Segregated streams to trickling filter where effluent to combine with DAF effluent to activated sludge and clarifier
50	Separate stabilization pond for sludge recirculation
51	Additional foul water stripping; IAF for ballast water
57	Activated sludge unit with pre-and post-filtration to be added along with surge pond
62	DAF units being added

TABLE VI-18 (Continued)

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
67	Activated sludge plant to be added
70	Segregate process and non-process wastewater and add oil to skimmer and filter
71	Segregate storm water; New API units and equalization pond; Increase lagoon aeration
72	Total renovation of barometric recycle water system
74	Possible addition of pH adjustment, chemical flocculation, and DAF
76	Equalization after API; Two new DAF units; Activated sludge unit; Final clarifier
77	Adding DAF, equalization, pH adjustment, activated sludge unit, and clarification
78	Add sour water stripper effluent and coker effluent to desalter
83	New equalization, bio-discs, and clarifiers after DAF, and sludge to be treated and digested
86	Storm water surge basin
87	All sour water to be evaporated
88	Adding two additional oil separators, and by-passing off-property water
90	Segregation of storm sewers and boiler blowdowns, and installation of bio-discs
92	Aerated lagoons to be converted to activated sludge; Biological treatment of storm runoff and ballast water; Cooling towers will be replaced by once-thru cooling water
95	Adding API separator
97	Adding activated sludge plant
98	Storm water segregation and overall plant modifications
102	New activated sludge plant including pH adjustment, chemical flocculation and settling, DAF unit, two parallel sludge reactor tanks and clarifiers, and final dual media filters; Also partial effluent recycle

TABLE VI-18 (Continued)

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
104	New impounding basin before aerated lagoon
105	Areated lagoon to be converted to activated sludge basins and to be followed by sand filters
106	Storm water segregation
107	Tie in to POTW
110	Boiler blowdown, sour water, desalter condensate, water treatment system blowdown, and spent caustic to be routed to new separator and into city sewer
114	Tie in to POTW
115	Storm water segregation; Separator effluent to pH adjustment, equalization, chemical floculation, DAF unit, activated sludge and clarification
120	Additional API separators and enlargement of aeration ponds; Activated carbon to be added if necessary
121	Plant source control programs
122	Stormwater segregation; Extra aerators to aeration basins; Mixed media filter for final effluent; Some recycle of final effluent to cooling water
124	Storm water retention pond
125	DAF unit to be installed
127	Baffles added to final polishing pond
132	Water treatment systems blowdown to clarifier; Segregate once-thru cooling water and un -contaminated runoff; Additional sour water stripper to allow reuse of stripped sour water; Effluent from separator, stripper, and clarifier to go to equalization, activated sludge, and filtration
142	Tie in to POTW
143	Tie in to POTW
150	Bio-discs to be added
151	Additional ammonia removal facilities; Bio-discs studies on aerated lagoon effluent

TABLE VI-18 (Continued)

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
152	Downflow sand filter to be added prior to final discharge
154	API separator to be added with new holding pond
163	API effluent to equalization pond with skimmer, four stage bio-disc unit, two parallel clarifiers, and final ponding with skimmers
165	Storm water runoff retention basin
168	Oily process wastewater, stripped sour water, and contaminated runoff to receive pH adjustment, oil water separation, sand filtration, equalization, nutrient addition, bio-disc treatment, and final clarification; ballast water to be held, fed to an IAF unit, passed through cooling water guard basin and discharged
172	Adding IAF, equalization, bio-discs, and clarification
173	API effluent to equalization, chemical addition, DAF, activated sludge, and clarification
175	To join regional treatment plant
177	Installation of bio-discs and clarifiers
181	API effluent to primary clarifiers before equalization
182	Expanded reuse of stripped sour water; Increased rainfall collection and retention facilities; All wastewater to POTW
184	Addition of chemical flocculation, DAF units, and cooling towers, and modification of aeration basin and clarifier
185	Add secondary treatment, effluent reuse, and, in 1981, solar evaporation
187	Larger API separator
190	Increase lagoon size
194	Improve API and polishing pond
199	Additional API separator
204	Modify DAF for recycle pressurization; Aerators in equalization pond; Dual media filters for bio-treator effluent; Improve chlorination; Better storm water segregation

TABLE VI-18 (Continued)

FUTURE WASTEWATER TREATMENT MODIFICATION

Refinery No.	Modifications
205	Sour water stripping systems; Larger API separator; Ponding or biological systems
208	Existing two parallel plate interceptors and three API separators to be replaced by five CPI units
212	Sand filtration for plant effluent
216	Aerated lagoon to be converted to activated sludge; New contaminated runoff impoundment facilities; Sour water oxidizer to be replaced by single stage stripper
219	Storm sewer effluent treatment to be improved; New CPI and equalization basin to be installed; Filter backwash to be dewatered in settling ponds and supernatant sent back to treatment plant intake
221	Equalization before aeration, and storm water segregation
222	Increase surge pond size; Chemical Floculation and clarification to be added; Effluent recycle facilities installed
230	IAF provided for API separator and equalization basin enlarged for grit removal
237	Storm water retention, activated sludge, and filtration under construction
236	New system to include API separator, holding tank,CPI, aerated equalization basin, four stage bio-disc unit, and final clarifier
240	New oil-water separator and existing pond to be subdivided into primary settling, aeration, and final settling
241	New parallel separator to combine with old separator and go to two parallel DAF units, activated sludge pond, clarifier, and final chlorination
242	Adding equalization basin after API separators, then chemical floculation, DAF, activated sludge, and final clarification
246	Total impoundment for all but once-thru cooling water
225	New API separator,additional treatment pond, DAF, new aeration basin, and phenolic treatment

TABLE VI-18 (Continued)

FUTURE WASTEWATER TREATMENT MODIFICATION

Refinery No.	Modification
256	Additional CPI to operate in parallel with existing one; Continuous solids removal to be added prior to API separator; Equalization basin capacity to be increased
257	Additional API separator, air flotation unit, and aerated lagoon
298	New system including primary separator, DAF, and secondary separator

TABLE VI-19

REFINERY FLOW VS. FINAL EFFLUENT CONCENTRATION FOR 17 SCREENING PLANTS

Refinery Code	Percent of Actual Discharge Flow to BPT Flow	Average BOD, mg/l	Average TSS, mg/l	Average TOC, mg/l	Average Oil and Grease, mg/l
A	40.8	< 2.5	37.0	11.0	*
B	37.8	18.5	22.0	43.0	34.0
C	36.7	41.0	19.0	39.0	9.0
D	49.7	125.0	62.0	220.0	*
E	143.3	< 9.5	14.5	10.0	*
F	.96	27.0	103.0	92.5	*
G	121.7	< 12.5	56.0	60.0	16.5
H	72.5	< 4.5	9.0	19.5	20.0
I	69.4	< 12.0	8.0	31.5	6.0
J	58.0	6.0	13.5	30.0	13.0
K	89.4	< 8.5	24.0	40.5	21.5
L	173.9	< 7.5	27.5	16.5	*
M	35.0	< 12.0	11.5	16.0	13.0
N	69.1	9.0	45.0	34.5	*
O	121.3	< 51.0	25.0	46.0	*
P	*	< 5.0	6.5	23.5	*
Q	28.0	25.0	30.0	68.5	41.0
Slope		- .11	- .15	- .31	- .11
Intercept		31.27	42.40	70.96	26.03
(Correlation)^2		.03	.08	.08	.09

Note: * - NO DATA

TABLE VI-20

REFINERIES INCLUDED IN THE DEVELOPMENT OF WASTEWATER FLOW REDUCTION FACTORS

Refineries Meeting Model Flow Only

Refinery Code No.	1 - R
127	0.004832
221	0.010752
239	0.018508
227	0.022324
78	0.024390
129	0.043977
264	0.046543
92	0.073705
225	0.078091
88	0.081830
188	0.106946
131	0.109219
156	0.110032
151	0.113357
245	0.113475
104	0.114422
205	0.118716
81	0.120256
153	0.122688
249	0.135178
149	0.143167
115	0.151155
236	0.154930
186	0.160188
84	0.165102
110	0.166667
265	0.170161
13	0.197342
142	0.197578
200	0.211340
45	0.211372
58	0.221726
41	0.237844
59	0.240990
24	0.247366
189	0.250000
96	0.257829
257	0.259934
89	0.260304
11	0.264403

Refineries Meeting Level 1 Only

Refinery Code No.	1 - R
111	0.265799
168	0.269221
234	0.273572
150	0.277283
252	0.277396
83	0.291458
232	0.297861
183	0.302376
190	0.308333
116	0.310503
85	.313123
73	.325362
163	0.331140
156	0.338431
224	0.357085
184	0.365553
256	0.369167
226	0.371728
162	0.382311
121	0.396491
228	0.399538
91	0.400000
159	0.407621
247	0.407631
235	0.419953
20	0.422332
157	0.432812
61	0.438513
219	0.444599
255	0.451475
44	0.452902
7	0.457237
258	0.462064
208	0.463856
212	0.473802
109	0.477875
128	0.479167
139	0.483395
71	0.490506
211	0.496587
201	0.502878
46	0.510246

Refineries Meeting Level 2

Refinery Code No.	1 - R	Refinery Code No.	1 - R
176	0.516635	137	0.716590
98	0.519890	147	0.717381
62	0.520057	108	0.720812
144	0.522209	22	0.729892
33	0.522553	260	0.733088
185	0.523294	140	0.746777
53	0.523628	50	0.748891
15	0.526985	202	0.750000
86	0.527967	118	0.752066
113	0.529121	179	0.755548
37	0.530348	243	0.768084
60	0.532317	8	0.772727
305	0.533266	103	0.774355
106	0.536462	25	0.778185
9	0.542311	310	0.783333
207	0.544872	191	0.792902
23	0.548148	36	0.795792
259	0.548640	3	0.807692
161	0.551402	54	0.820523
119	0.555687	10	0.826075
14	0.561105	237	0.835294
16	0.562280	165	0.846560
114	0.568072	17	0.848736
206	0.569444	220	0.850649
77	0.569981	49	0.858620
6	0.572893	80	0.861077
124	0.595636	99	0.864288
2	0.600592	107	0.903723
26	0.607326	97	0.915076
158	0.612115	254	0.916667
233	0.628336	229	0.925180
210	0.638888	19	0.945128
264	0.641834	193	0.949884
298	0.650538	218	0.970833
195	0.667500	31	0.971374
187	0.668071	141	0.978270
18	0.670520	4	0.989423
90	0.671052	302	0.990476
125	0.678214	248	0.997499
160	0.687500	135	1.000000
55	0.688612	250	1.000000
1	0.690352	251	1.000000
213	0.699307	278	1.000000
209	0.701322	296	1.000000
74	0.703493	303	1.000000
155	0.705220	307	1.000000
148	0.715018		

Notes: 1. Of the 262 refineries included in the project data base, 175 refineries are known to have generated wastewaters in 1976 at a rate less than their model flows based upon crude throughputs.

2. $$R = \frac{\text{Wastewater Generated in 1976}}{\text{Model Flow based upon Crude Throughput in 1976}}$$

R_1 for Level 1 = 0.73
R_2 for Level 2 = 0.48

SECTION VII

COST, ENERGY AND NON-WATER QUALITY ASPECTS

INTRODUCTION

This section addresses the costs, energy requirements and non-water quality environmental impacts associated with the control and treatment technologies presented in Section VI. As such, the cost estimates represent the incremental expenditures required over and above the capital and operating costs associated with attainment of BPT effluent limitations. These differential costs, therefore, relate to specific control and treatment alternatives that could be necessary to comply with BAT limitations.

The cost estimates presented do not include land costs; the cost of land is variable and site dependent and cannot be estimated on a national basis. However, the amount of land required is indicated for each of the major end-of-pipe treatment schemes. It should be noted that these land requirements are minimal compared to the land requirements for refinery process equipment and land at the refinery for wastewater treatment systems exists in most cases. All costs presented in this section are based upon January 1977 values.

The cost data presented in this section are based on flow rates. basis. The following table outlines the cost basis used for calculating the major capital and operating costs presented in this section:

Table VII-1

COST BASIS

Item	Unit Cost
1. Tank Steel	\$1.40 - 2.00/pound
2. Tank Lining	\$3.00 - 4.00/ft^2
3. Carbon, granular (capital cost)	\$31.00/ft^3
4. Carbon, granular (operating cost)	\$0.61/lb
5. Carbon, powdered (operating cost)	\$0.31/lb
6. Electricity	\$0.04/kilowatt hr.
7. Manpower	\$10.00/hr

Capital costs for major equipment items such as clarifiers, filters, carbon regeneration furnaces, solids dewatering filters, activated carbon, and large pumps were obtained from equipment manufacturers. Other costs such as the unit cost of tank steel, piping, small pumps, etc. were derived from the contractor's (Burns and Roe) in-house experience and expertise in the design and construction of major facilities.

The depreciation factor and the cost of capital have not been included in these cost presentations but will be considered in the economic impact analysis.

COST AND ENERGY REQUIREMENTS OF TECHNOLOGIES CONSIDERED

Biological Treatment. Cost analyses developed for BPT regulations were based on activated sludge or equivalent BPT systems (3). Very limited number of refineries may need to upgrade their existing biological treatment systems inorder to comply with BAT limitations.

One method of upgrading a biological unit is to install a raw wastewater equalization system (143). Table VII-2 presents capital and operating costs for this type of modification. These costs are based upon 12 hours detention and include the necessary pumps and controls for equalization of flow as well as pollutant loading.

EPA assumes the tanks are manufactured by placing a steel shell on a concrete pad. Costs are included for pumping the wastewater either to or from the equalization tank. It is assumed either that pumping is not required on both sides of the tank, or there is one set of existing pumps to supply the second pumping requirement.

Another method of improving the performance of a biological treatment system is to install a biological roughing unit. Rotating biological contactors (RBC's) are an applicable treatment alternative for use as a roughing system.

Tables VII-3 and VII-4 present equipment sizes and energy requirements, as well as capital and operating costs for RBC units. This study assumes that this treatment alternative will be used if aerated lagoons or oxidation ponds are used as the basic biological treatment process. The use of aerated lagoons and oxidation ponds implies that the refinery has sufficient land to install this type of wastewater treatment system.

It also is assumed that the RBC units will procede the present biological system. Clarifiers, or additional sludge handling capabilities, will not be required, since the amount of solids carry-over from the RBC units to the present lagoons is assumed to be the same order of magnitude as that presently entering the lagoons from the raw wastewater.

Refineries with activated sludge or trickling filter systems can improve their effluent quality with powdered activated carbon treatment. Powdered activated carbon may also improve the effluent quality of trickling filter systems. Tables VII-5 through VII-7 present cost data for powdered activated carbon systems that do not include the cost of sludge handling in the analysis. However, when carbon regeneration is used in conjunction with powdered activated carbon treatment, the sludge produced in the biosystem is incinerated as the carbon is regenerated, thus eliminating the sludge disposal costs associated with this requirement. An analysis was undertaken to determine when the use of carbon regeneration would become cost effective when sludge handling is included as a cost factor. This analysis is included in Table VII-8. Tables VII-9 through VII-11 present cost data for powdered activated carbon systems based upon the inclusion of sludge handling costs.

Table VII-10 includes the costs for purchase of solids dewatering systems, whereas Table VII-11 includes operating costs with sludge disposal shown as a credit for the systems that include carbon regeneration.

The powdered activated carbon costs described above are based upon an 80 mg/l dosage rate. This number is based upon one year of operating data at the DuPont Chambers works facility.

Filtration. Filtration was also discussed in Section VI. BPT regulations were based, in part, on granular media filtration or polishing ponds (3). Many refineries do not include filtration or other polishing techniques in their present systems, even though that technology was included in the model BPT technology. It may be necessary for certain refineries to install granular media filtration to comply with BAT limitations. Tables VII-12 and VII-13 include the associated cost data for tertiary filtration systems.

Granular Activated Carbon. Table VII-14 presents the equipment sizes and energy requirements used to estimate the capital and operating costs for granular activated carbon systems. The sizes are based upon the design concept described in Section VI, with the system consisting of tanks that can be shipped in one piece, thereby minimizing field construction. This results in an unusually large number of tanks for the larger systems. In reality, a more cost-effective design (with cost savings on the order of 5 to 15%) for a given refinery could use field constructed steel tanks, concrete tanks, or other construction techniques determined on a plant-by-plant basis. The use of similar sized, shop fabricated tanks allows for uniformity in cost estimating, especially in regard to the development of construction and design engineering estimates. This approach also results in a conservative (e.g., larger) estimate, and is considered preferable when considering general industry-wide costs.

Table VII-15 presents the capital costs for the systems outlined in Table VII-14. Table VII-16 provides the operating costs, excluding depreciation, for these granular activated carbon systems. The capital costs for carbon regeneration systems are based upon an equipment manufacturer's quotations.

The manhour estimates used in carbon regeneration calculations were based on the following: Manpower requirements for the operation of the granular carbon adsorbers were obtained from the EPA Technology Transfer Series, Carbon Adsorption Manual (64); the manpower estimates for operating powdered carbon feed systems were assumed to be half of those for the granular systems. The estimates presented in this reference for the operation of carbon regeneration systems appear to have significant errors (on the order of 5 to 10 times too large), so that they were not used in this analysis. Based on other experience in operating a system of this type, it is estimated that one operator around the clock would be required for the operation of a carbon regeneration system, and this value has been used in the analysis.

One equipment supplier leases carbon adsorption systems. Plants would pay a yearly operating cost with no initial investment other than a foundation for and piping to the equipment. This supplier has suggested the following rental cost estimates for the two smallest systems:

I. 380 M^3/day (0.1x10^6 gal/day) - $75,000 - $100,000/year
Foundation and Hook-up - $5,000
II. 3800 M^3/day (1.0x10^6 gal/day) - $450,000/year
Foundation and Hook-up - $15,000

These estimates are based upon a lease agreement for a minimum of three years and include the carbon adsorbers, with installation, all granular carbon required, and carbon regeneration services. Manpower for the operation of the carbon columns is not included.

Powdered Activated Carbon. Powdered activated carbon treatment can also be used for the removal of organic toxic pollutants, but may require higher carbon dosages. Tables VII-17 thru VII-19 present costs for powdered activated carbon systems based upon a carbon dosage of 150 mg/l. Tables VII-20 thru VII-23 present the analyses and associated results when the costs for sludge hauling and recognized.

Low Flow Rate Systems. Table VII-24 presents capital and operating costs for the systems discussed above at a design flow rate of 10,000 gal/day.

In-Plant Control

Chromium Removal. The treatment technology described in Section VI is the basis for estimating the costs of chromium removal. Most refineries also can take advantage of the reducing environment in refinery sewers and the removal capabilities of secondary treatment systems.

Table VII-25 presents cooling tower blowdown rates for the refineries that responded to the 1977 EPA Petroleum Refining Industry Survey. The flow rates have been used as the design basis for chromium treatment systems. Table VII-26 presents equipment cost bases and energy requirements for selected flow rates from Table VII-25; Table VII-27 presents the capital and operating costs for these same systems.

Flow Reduction. Section VI describes a number of in-plant control measures designed to reduce or elminate wastewater flow. Many of these measures, however, require a plant-by-plant evaluation to determine their usefulness. In addition, the costs associated with their implementation are for the most part site dependent, making an accurate estimation of representative costs on a national basis very difficult.

The Agency has selected one in-plant flow reduction measure, however, that can be applied at most refineries in the country, and whose cost can be readily estimated on a national scale. This flow reduction scheme consists of the recycling of treated refinery wastewaters for use in such process related applications as cooling tower make-up, pump gland cooling water, wash down water, and fire system water. This wastewater could be reused once, and then returned to the refinery wastewater collection system for end-of-pipe treatment. The amount of wastewater that can be recycled in this manner depends on many factors, including the number of cooling towers in the plant, the salinity of the wastewater to be recycled, etc. EPA has chosen this wastewater reduction technique for estimating purposes because it is both definable and representative of the costs that would be incurred by other similary effective in-plant control measures.

Table VII-28 presents the capital and operating costs per mile for recycling various amounts of treated wastewater. Figure VII-1 shows this data in curvilinear form, projecting the cost values in Table VII-28 over a wide range of pumping distances.

Determining the costs incurred at a particular refinery requires information on the distance between the treated wastewater collection point and the actual point of reuse. Since this data is not generally available, it is necessary to estimate based upon refinery size. Figure VII-2 presents a curve of refinery size vs. pumping distance. This figure is presented to permit an estimate of the cost for reuse of treated wastewater. EPA expects that the costs developed using Figures VII-1 and VII-2 will be higher than the actual cost experienced at most refineries. This is because the distances derived from Figure VII-2 probably will be higher than the actual distances involved at most petroleum refineries.

Treatment of Recycled Wastewater. In some cases, particularly for cooling tower make-up, the recycled wastewater may require treatment for the removal of calcium and magnesium hardness. This type of treatment may involve the use of lime or lime-soda ash softening, followed by filtration. Table VII-29 presents the capital costs for softening systems that correspond to the flow rates utilized in Table VII-28. Operating costs cannot be readily determined on a national basis because they are heavily dependent on the concentration of calcium and magnesium in the recycled wastewater. Lime costs can range from roughly $0.025/1000 gal. of treated water, for an influent hardness of 100 mg/l (as $CaCO_3$), to $0.12/1000 gal. for an influent hardness of 500 mg/l (as $CaCO_3$). These costs can vary depending on the desired effluent quality and on the influent water quality, especially in regard to alkalinity.

NON-WATER QUALITY ASPECTS

Solid Wastes

In general, the treatment systems described in Section VI produce relatively small amounts of solid waste with regard to large powdered activated carbon systems, the sludges may be incinerated, which actually reduces or eliminates the solid wastes produced by these biological treatment facilities. For smaller powdered activated carbon systems that do not include regeneration, the inclusion of powdered carbon in the sludge has been shown to improve sludge settleability (61), so that the volume of sludge requiring disposal should not increase significantly, and in fact, may decrease.

Sludge is produced from lime softening systems and from the application of chromium removal techniques. The Agency anticipates, however, that only a limited number of refineries would require these types of treatment. The cost of handling this sludge has not been included in the cost estimates presented in this section. These sludges would require land disposal, because they are not biodegradeable. However, the cost and environmental impact of this type of disposal is assumed to be minimal on a national basis, especially when compared to the large quantities of sludges produced by BPT type technology. The cost and environmental impact on a plant-by-plant basis cannot be determined, because the quantity of sludge is heavily dependent on the hardness of the water being treated and on the chromium concentration in the wastewater.

Air Pollution

The carbon regeneration furnaces associated with both granular and powdered activated carbon systems will produce airborne contaminants. However, the equipment costs and operating requirements presented in this section for regeneration systems include after-burners for hydrocarbon and carbon monoxide removal and air scrubbing equipment for particulate removal.

COSTS AND EFFECTIVENESS OF TECHNOLOGY OPTIONS

EPA is presently considering six regulatory options for direct dischargers and two regulatory options for indirect dischargers. Plant-by-plant costs for two of the six direct discharge alternatives and both of the indirect discharge alternatives are presented below.

Direct Discharge Options

Costs are presented in Table VII-30 for the following options:

Option 1 - Set BAT regulations based upon BPT end-of-pipe treatment with an average reduction in effluent flow of 27% (refer to discussion on reuse in Section VI).

Option 2 - Set BAT regulations based upon 52% pollutant loading reductions. This level of reduction can be achieved via 52% flow reduction (refer to discussion on reuse in Section VI) or a combination of limited flow reduction and end-of-pipe treatment such as powdered activated carbon or rotating biological contactors (RBC's). Cost for this option is based upon 27% flow reduction (same as Option 1) with biological enhancement using powdered activated carbon or rotating biological contactors.

The following general assumptions have been made in developing the costs:

1. In order to comply with a given BAT option, it is assumed that the refinery must reduce its flow and install a "model" end-of-pipe treatment system. Refineries already having these technologies or planning to install them have no costs. It is assumed that all refineries have some type of biological treatment already in place.

2. Although there are many methods to reduce flow, recycle of treated wastewater is easily definable in terms of developing costs and will be the assumed technique for each refinery that requires effluent reduction. Although a given refinery may choose a different method, the costs allocated are expected to be conservatively high.

3. Although a refinery may choose to upgrade its biological treatment system in other ways, rotating biological contactors (RBC) and powdered activated carbon can be readily priced as add-on systems. Costs for these systems also are expected to be conservatively high estimates.

4. Although the costs are based on one approach to achieving effluent quality, there are many alternatives available to this industry. A given refinery may choose to add sophisticated end-of-pipe treatment systems, rather than reduce flow. Alternatively, a refinery may choose to drastically reduce its flow and install minimal end-of-pipe treatment. However, in order to produce conservatively high costs within a reasonable manhour expenditure, the costs rely heavily on end-of-pipe treatment alternatives, which can be directly defined. The cost procedures include reducing flow to Option 1 requirements only. Beyond this, sophisticated end-of-pipe treatment (biological polishing with RBC's or powdered activated carbon) were used to represent the costs associated with meeting Option 2 requirements.

5. Effluent flow is considered to be the flow indicated in the NPDES permit. All other forms of disposal (i.e., evaporation, deep well, etc.), except indirect discharge, were considered flow reduction techniques.

6. Some refineries discharge partly to POTW's and partly to surface waters. Only those plants that directly discharge the majority of their wastewaters were included in this analysis. For these plants, the wastewater discharged to a POTW was assumed to be included with the direct discharge flow.

The costs were developed using a model technology for each regulatory option, as follows:

Option	Flow Reduction	End-of-Pipe Treatment Reqd
1	27%	Bio Treatment
2	52%	activated carbon or RBC's

The costs for each refinery were generated by adding those treatment operations that did not exist in 1976, and were not listed as planned for the future. Since biological treatment is essential to meeting the BPT guidelines, this level of treatment was assumed to exist at all direct discharging refineries, whether or not they were in-place or were planned for the future.

Therefore, a plant was assumed to be meeting BPT with their system as it existed in 1976, with the inclusion of planned treatment improvements. Costs were then calculated for those additional treatment techniques necessary for completing the "model treatment" train.

Planned flow reductions also were included in this analysis where they were applicable to the costs for meeting the BAT limitations. A detailed description of those flow reductions considered and those ignored are presented in the March 1979 Cost Manual (151).

The energy requirements for meeting these two options are as follows:

Option	Industry Energy Requirements, Kwh/yr
1	5,500,000
2	5,800,000

These estimates were calculated using four model plant sizes, which represent four equal segments of the direct discharge segment of the industry, as follows:

Model Plant	Capacity, BBL/day	Discharge Flow Rate, 10^6 gal/day
1	10,000	0.052
2	50,000	0.3
3	65,000	0.86
4	200,000	5.1

Each model plant represents approximately 20 plants in its size range.

Estimates of the additional sludge generated by these technologies are as follows:

Option	Sludge Generation, Pounds of Dry Solids Per Year
1	0
2	31,000,000

The estimate for Option 2 is based upon the installation of powdered activated carbon at all plants. This allows for a conservatively high estimate since plants that choose to use RBC's will only have a minor increase in sludge generation.

Indirect Discharge Options

There are two indirect discharge options being considered by EPA. These are as follows:

Option 1 - Set standards based upon the treatment of chromium in the cooling tower blowdown stream.

Option 2 - Set standards equal to BPT end-of-pipe treatment technology, namely flow reduction, equalization, biological treatment, and filtration.

Table VII-31 presents the costs associated with meeting Option 1. Where the cooling tower blowdown rate was not known, it was assumed to be one-fourth of the total effluent flow. The analysis also included the cost of combining the effluents from multiple tower installations. The costs presented for recycle of treated effluents (Table VII-28 and Figure VII-1) were used to obtain the estimates for the necessary pumps and piping.

Table VII-32 presents the costs associated with meeting Option 2. Costs for the installation of in-plant control measures were assigned to plants whose wastewater flow was greater than their calculated BPT flow. These costs were obtained from the National Commission on Water Quality (20), which included the following control measures:

Sour Water Stripping
Conversion of Barometric Condensers
Collection and Treatment of Contaminated Storm Water
Collection and Treatment of Contaminated Ballast Water
Spent Caustic Neutralization, Oxidation, or Disposal
Reuse of Sour Water in Desalter
Reuse of Coker Cutting Water

The costs presented in this document were updated to January 1977 by using a correction factor of 1.184. This factor is based upon the Engineering News-Record index.

Costs for end-of-pipe treatment were obtained from the 1974 development document (3), using alternatives B and C, as follows:

B. Biological treatment, consisting of activated sludge units, thickeners, digestors, and dewatering facilities.

C. Granular media filtration, consisting of filter systems and associated equipment.

These costs also were corrected to January 1977 values using a factor of 1.22 derived from the Engineering News-Record index.

Industry-wide energy consumption and sludge generation estimates have been prepared for Option 1, chromium removal. These estimates are as follows:

Energy consumption, Kwh/yr - 1,900,000
Sludge generation, pounds per year - 2,200,000

EPA developed these costs by estimating the values for each plant requiring chromium removal.

New Sources

The Agency expects that grass roots refineries built in the next five years will be in the size of 150,000 bbls/day, with at least topping and cracking processes. It is assumed that such a refinery will generate a flow of 3,340,000 gallons per day. Based upon the flow rate, the costs over BPT for meeting BAT Option 2 for this model size plant include:

Capital Costs	$615,000
Operating Costs	$284,000

EPA has not calculated the costs for eliminating wastewater discharge. However, the API publication "Water Reuse Studies"(150) has presented such costs for a 150,000 barrel per day grass roots refinery. This document estimates an additional investment, over BPT, of $9.5 million with an annual cost of $3.5 million, including interest and depreciation (1977 dollars).

Effectiveness of Guidelines

Tables VII-33 and VII-34 present the estimated pollutant removal from BPT to the two BAT options for the direct discharging refineries. Pollutant removals for BOD, TSS, Oil and Grease, chromium (hexavalent and total), and phenol are presented.

Option 1 for pretreatment standards requires the removal of chromium from cooling tower blowdown to a daily maximum level of 1 mg/l. In addition, the Agency is proposing a maximum concentration of 100 mg/l for oil and grease and ammonia. However, the data collected during this study indicate that these values are of the same order of magnitude found in raw refinery wastewater; therefore, the effectiveness of these limitations cannot be quantified.

Proposed NSPS for the model size plant of 150,000 bbls/day will remove 2.46 lbs/day phenol, 3.9 lbs/day hexavalent chromium, 6 lbs/day total chromium, 308 lbs/day total syspended solids, and 381 lbs/day BOD.

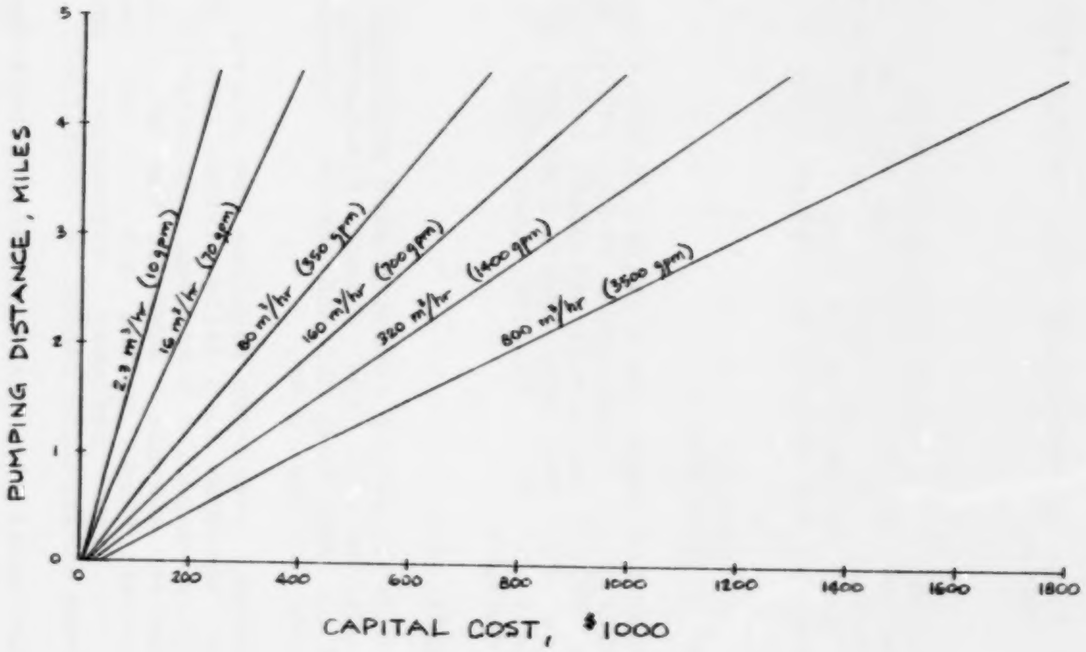


FIGURE VII-1

Pumping Capital Cost vs. Pumping Distance

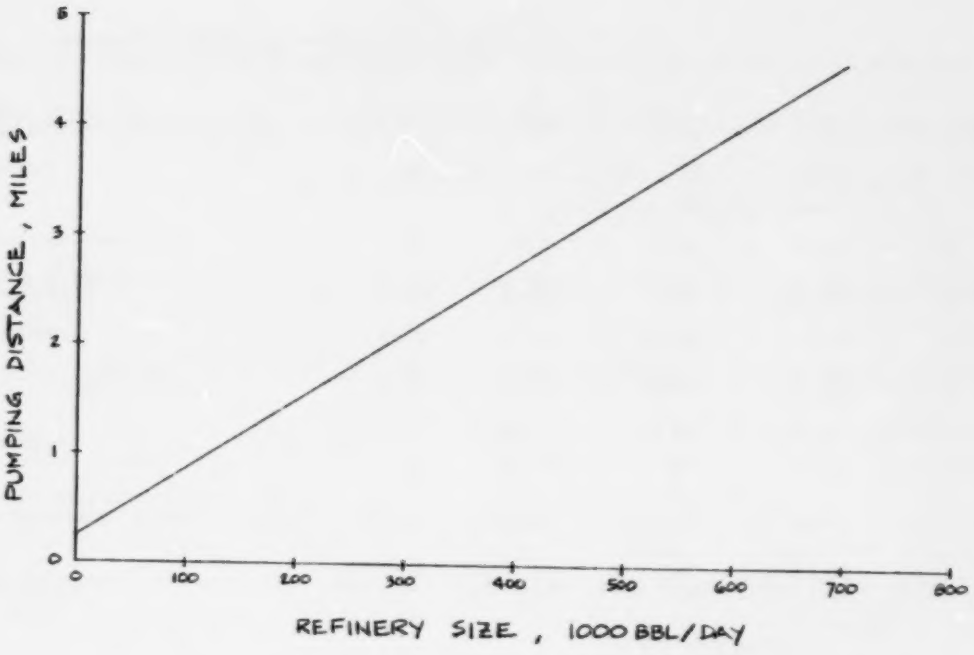


FIGURE VII-2

Refinery Size vs. Pumping Distance

TABLE VII-2

RAW WASTEWATER EQUALIZATION SYSTEMS
CAPITAL AND OPERATING COSTS

Description	380 ^{3}/day (0.1 x 10^6) gal/d	3800 ^{3}/day (1.0 x 10^6) gal/d	19,000 ^{3}/day (5 x 10^6) gal/d	38,000 ^{3}/day (10 x 10^6) gal/d	76,000 ^{3}/day (20 x 10^6) gal/d
	Capital Cost, Dollars				
Detention tank, 12 hours detention, steel shell on concrete pad	$ 30,000	$ 116,000	$ 346,000	$ 595,000	$1,020,000
Pumps, and associated controls, installed	8,000	30,000	87,000	149,000	255,000
Subtotal	$ 38,000	$ 146,000	$ 433,000	$ 744,000	$1,275,000
Piping, installed (15%)	5,700	22,000	65,000	117,000	192,000
Total Installed Cost	$ 43,700	$ 168,000	$ 498,000	$ 861,000	$1,467,000
Engineering	6,650	26,000	75,000	129,500	221,500
Contingency	6,650	26,000	75,000	129,500	221,500
Total Capital Cost	$ 57,000	$ 220,000	$ 648,000	$1,120,000	$1,910,000
Land Requirements, ft^2	585	5,780	28,200	57,600	113,000
	Annual Operating Costs, Dollars				
Pumping	$ 140	$ 1,400	$ 7,000	$ 14,000	$ 28,000
Maintenance (3% of Capital Cost)	1,700	6,600	19,500	33,600	57,300
Total Annual Cost	$ 1,840	$ 8,000	$ 26,500	$ 47,600	$ 85,300

Note: The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-3

ROTATING BIOLOGICAL CONTACTORS (RBC's)
AS ROUGHING SYSTEMS
EQUIPMENT COST BASIS
AND ENERGY REQUIREMENTS

Description	Equipment Size				
	380 m^3/day (0.1 x 10^6) gal/d	3800 m^3/day (1.0 x 10^6) gal/d	19,000 m^3/day (5 x 10^6) gal/d	38,000 m^3/day (10 x 10^6) gal/d	76,000 m^3/day (20 x 10^6) gal/d
Design Percent Removal of BOD	50	50	50	50	50
Number of Units	1	6	24	48	96
Shaft Lengths, each	15	20	25	25	25
Total Square Feet of Surface Area	75,000	630,000	3,200,000	6,400,000	12,800,000
	Annual Operating and Energy Requirements				
Manpower Requirements, hours	500	750	1,000	1,500	2,000
Power Requirements, kWh/yr	33,000	294,000	1,180,000	2,360,000	4,720,000

TABLE VII-4

ROTATING BIOLOGICAL CONTACTORS (RBC's)
AS ROUGHING FILTERS
CAPITAL AND OPERATING COSTS

Description	380 m^3/day (0.1 x 10^6) gal/d	3800 m^3/day (1.0 x 10^6) gal/d	19,000 m^3/day (5 x 10^6) gal/d	38,000 m^3/day (10 x 10^6) gal/d	76,000 m^3/day (20 x 10^6) gal/d
			Capital Cost, Dollars		
RBC Units, Steel Shell, Fiberglass Cover	$ 46,000	$340,000	$1,590,000	$3,170,000	$6,340,000
Piping	5,000	35,000	160,000	317,000	634,000
Total Equipment Cost	51,000	375,000	1,750,000	3,487,000	6,974,000
Installation (50%)	25,500	187,500	875,000	1,744,000	3,487,000
Total Constructed Cost	76,500	562,500	2,625,000	5,231,000	10,461,000
Engineering	11,750	84,750	397,500	784,500	1,569,500
Contingency	11,750	84,750	397,500	784,500	1,569,500
Total Capital Cost	$100,000	$732,000	$3,420,000	$6,800,000	$13,600,000
Land Required, ft^2	420	2,800	13,500	27,000	54,000
			Annual Operating Costs*		
Power	$ 1,500	$ 12,000	$ 48,000	$ 95,000	$ 190,000
Labor	5,000	7,500	10,000	15,000	20,000
Maintenance (3% of Total Capital Cost)	3,000	22,000	103,000	204,000	408,000
Total Annual Cost	$ 9,500	$ 41,500	$ 161,000	$ 314,000	$ 798,000

Note: The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-5

POWDERED ACTIVATED CARBON
EQUIPMENT COST BASIS
AND ENERGY REQUIREMENTS
80 mg/l DOSAGE RATE

Description	Equipment Size				
	$380 m^3/day$ (0.1×10^6) gal/d	$3800 m^3/day$ (1.0×10^6) gal/d	$19,000 m^3/day$ (5×10^6) gal/d	$38,000 m^3/day$ (10×10^6) gal/d	$76,000 m^3/day$ (20×10^6) gal/d
Powdered Carbon Feed Tanks (2 each) Capacity, gallons (Based on feed concentration of one pound carbon/gallon water)	700	7,000	35,000	70,000	140,000
Feed Rate pounds/day	67	670	3,350	6,700	13,400
	Annual Operating and Energy Requirements				
Manpower Requirements, hours	400	540	940	1,240	1,940
Miscellaneous Power Requirements, kWh/yr	25,000	50,000	125,000	200,000	375,000

TABLE VII-6

POWDERED ACTIVATED CARBON
CAPITAL COSTS
80 mg/l DOSAGE RATE

Description	Capital Costs, Dollars				
	380 m^3/day (0.1 x 10^6) gal/d	3800 m^3/day (1.0 x 10^6) gal/d	19,000 m^3/day (5 x 10^6) gal/d	38,000 m^3/day (10 x 10^6) gal/d	76,000 m^3/day (20 x 10^6) gal/d
Powdered Carbon Feed System	$10,000	$30,000	$45,000	$60,000	$100,000
Piping	1,000	3,000	4,500	6,000	10,000
Total Equipment Cost	11,000	33,000	49,500	66,000	110,000
Installation (50%)	6,000	16,500	24,800	33,000	55,000
Total Constructed Cost	17,000	49,500	74,300	99,000	165,000
Engineering	9,000	10,000	11,350	15,500	25,000
Contingency	9,000	10,000	11,350	15,500	25,000
Total Capital Cost	$35,000	$69,500	$97,000	$130,000	$215,000
Land Requirements, ft^2	100	200	900	1,300	1,700

TABLE VII-7

POWDERED ACTIVATED CARBON
ANNUAL OPERATING COSTS
80 mg/l DOSAGE RATE

Description	Annual Cost, Dollars				
	380 m^3/day (0.1 x 10^6) gal/d	3800 m^3/day (1.0 x 10^6) gal/d	19,000 m^3/day (5 x 10^6) gal/d	38,000 m^3/day (10 x 10^6) gal/d	76,000 m^3/day (20 x 10^6) gal/d
Carbon Make-Up	$ 7,400	$74,000	$370,000	$740,000	$1,480,000
Miscellaneous Power Requirements	1,000	2,000	5,000	8,000	15,000
Labor ($10/manhour)	4,000	5,400	9,400	12,400	19,400
Maintenance (3% of total Capital Cost)	1,000	2,000	3,000	4,000	6,600
Total Annual Cost	$13,400	$83,400	$387,400	$764,400	$1,521,000

Note:

The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-8

POWDERED ACTIVATED CARBON

COMPARISON OF OPERATING COSTS
CARBON REGENERATION VS. THROW-AWAY
80 mg/l DOSAGE RATE

Item	380 m^3/day (0.1 x 10^6) gal/d	3800 m^3/day (1.0 x 10^6) gal/d	19,000 m^3/day (5 x 10^6) gal/d	38,000 m^3/day (10 x 10^6) gal/d	76,000 m^3/day (20 x 10^6) gal/d
			Regenerated		
Capital Cost	$735,000	$1,000,000	$1,650,000	$2,300,000	$3,250,000
Carbon Make-Up	$ 2,200	$ 22,000	$ 110,000	$ 220,000	$ 440,000
Furnace Power	5,000	19,000	44,000	76,000	132,000
Miscellaneous Power	1,000	2,000	5,000	8,000	15,000
Labor	91,600	93,000	97,000	100,000	108,000
Maintenance (3%)	1,000	2,000	3,000	4,000	6,600
(15%)	105,000	140,000	233,000	328,000	455,000
Depreciation (27%)	200,000	270,000	446,000	621,000	878,000
Total Annual Cost	$405,800	$ 548,000	$ 938,000	$1,357,000	$2,034,600
			Non-Regenerated		
Capital Cost	$ 35,000	$ 39,500	$ 97,000	$ 130,000	$ 215,000
Carbon Make-Up	$ 7,400	$ 74,000	$ 370,000	$ 740,000	$1,480,000
Labor	4,000	5,400	9,400	12,400	19,400
Maintenance (3%)	1,000	2,000	3,000	4,000	6,600
Miscellaneous Power	1,000	2,000	5,000	8,000	15,000
Depreciation (27%)	9,500	17,600	26,200	35,100	58,000
Total Annual Cost	$ 22,900	$ 101,000	$ 413,600	$ 799,500	$1,579,000
Cost for Sludge Dewatering	$ 20,000	$ 76,000	$ 137,000	$ 226,000	$ 335,000
Annual Cost with Sludge Dewatering	$ 42,900	$ 177,000	$ 550,000	$1,025,000	$1,914,000
Cost for Land Disposal	4,000	40,000	200,000	400,000	800,000
Annual Cost with Land Disposal	$ 46,900	$ 217,000	$ 750,000	$1,425,000	$2,714,000

TABLE VII-9

POWDERED ACTIVATED CARBON
EQUIPMENT COST BASIS
AND ENERGY REQUIREMENTS
INCLUDING COSTS FOR SLUDGE DISPOSAL
80 mg/l DOSAGE RATE

Description	Equipment Size 380 m^3/d (0.1 x 10^6) gal/d	 3800 m^3/d (1.0 x 10^6) gal/d	 19,000 m^3/d (5 x 10^6) gal/d	 38,000 m^3/d (10 x 10^6) gal/d	 76,000 m^3/d (20 x 10^6) gal/d
Powdered Carbon Feed Tanks (2 each) Capacity, gallons (Based on feed concentration of one pound carbon/gallon water)	700	7,000	35,000	70,000	140,000
Feed Rate, lb/d	67	670	3,350	6,700	13,400
Sludge handling and/or regeneration system, lb/d dry solids	290	2,900	14,600	29,000	58,000
	Annual Operating and Energy Requirements				
Carbon make-up lb/d	67	670	3,350	2,000	4,000
Furnace power requirements					
Fuel, Btu/h	N.A.	N.A.	N.A.	2,500,000	4,500,000
Connected hp	N.A.	N.A.	N.A.	100	140
Manpower requirement, hours	400	540	940	10,000	10,700

TABLE VII-10

POWDERED ACTIVATED CARBON
CAPITAL COSTS
INCLUDING COSTS FOR SLUDGE DISPOSAL
80 mg/l DOSAGE RATE

Description	Capital Costs, Dollars				
	380 m^3/d (0.1x10^6 gal/d)	3800 m^3/d (1.0x10^6 gal/d)	19,000 m^3/d (5x10^6 gal/d)	38,000 m^3/d (10x10^6 gal/d)	76,000 m^3/d (20x10^6 gal/d)
Powdered Carbon Feed System	$10,000	$30,000	$45,000	$60,000	$100,000
Solids Dewatering System	--	--	--	397,000	585,000
Regenerated Carbon Acid Wash System	--	--	--	40,000	60,000
Subtotal	10,000	30,000	45,000	497,000	745,000
Piping (10%)	1,000	3,000	4,500	49,700	74,500
Total Equipment Cost	11,000	33,000	49,500	546,700	819,500
Installation (50%)	5,500	16,500	24,800	273,400	410,000
Total Constructed Cost	16,500	49,500	74,300	820,100	1,229,500
Engineering	9,000	10,000	11,350	119,950	185,250
Contingency	9,000	10,000	11,350	119,950	185,250
Subtotal	35,000	69,500	97,000	1,060,000	1,600,000
Activated Carbon Regeneration System (Installed)	--	--	--	900,000	1,200,000
Contingency (For Utility Hook-up, etc.)	--	--	--	190,000	250,000
Engineering for Carbon Regeneration System	--	--	--	150,000	200,000
Total Capital Cost	$35,000	$69,500	$97,000	$2,300,000	$3,250,000
Land Requirements, ft^2	100	200	900	3,000	4,500

TABLE VII-11

POWDERED ACTIVATED CARBON
ANNUAL OPERATING COSTS
INCLUDING CREDIT FOR SLUDGE DISPOSAL
80 mg/l DOSAGE RATE

	Annual Cost, Dollars				
Description	380 m^3/day (0.1 x 10^6) gal/d	3800 m^3/day (1.0 x 10^6) gal/d	19,000 m^3/day (5 x 10^6) gal/d	38,000 m^3/day (10 x 10^6) gal/d	76,000 m^3/day (20 x 10^6) gal/d
Carbon Make-Up	$7,400	$74,000	$370,000	$220,000	$440,000
Furnace Power	---	---	---	76,000	132,000
Miscellaneous Power Requirements	1,000	2,000	5,000	8,000	15,000
Labor ($10/manhour)	4,000	5,400	9,400	100,000	108,000
Sludge Disposal Credit	---	---	---	(-)400,000	(-)800,000
Maintenance	1,000	2,000	3,000	332,000	461,600
Total Annual Cost	$13,400	$ 83,400	$387,000	$336,000	$ 356,000

Note:
The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-12

TERTIARY FILTRATION
EQUIPMENT COST BASIS AND ENERGY REQUIREMENTS

Description	Equipment Cost Basis				
	380 m^3/ day	3800m ^{3}/day	19,000 m^3/day	38,000 m^3/day	76,000 m^3/day
	(0.1 X 10^6gal/d)	(1 X 10^6gal/d)	(5 X 10^6gal/d)	(10 X 10^6gal/d)	(20 X 10^6gal/d)
Filter Description (all units are automatic and air scoured)	2 units 5' diam., steel	2 units 11' diam., steel	1 unit, 4-35' square cells, concrete	1 unit, 4-47' square cells, concrete	2 units, 47' square cells, concrete
Bed depth, ft	4	4	4	4	4
Operation type	Gravity	Gravity	Gravity	Gravity	Gravity
Media type	Dual media	Dual media	Dual media	Dual media	Dual media
	Annual Operating and Energy Requirements				
Pumping, kWh/yr	3,440	34,400	172,000	344,000	688,000
Labor, Manhours/year	400	500	600	700	800

TABLE VII-13

TERTIARY FILTRATION
CAPITAL AND OPERATING COSTS

Description	380 m^3/day (0.1 x 10^6) gal/d	3800 m^3/day (1.0 x 10^6) gal/d	19,000 m^3/day (5 x 10^6) gal/d	38,000 m^3/day (10 x 10^6) gal/d	76,000 m^3/day (20 x 10^6) gal/d
	Capital Cost, Dollars				
Filtration Units Installed	$ 25,000	$100,000	$250,000	$350,000	$600,000
Interconnecting Piping, Installed	3,000	10,000	25,000	35,000	60,000
Pumps, Installed	5,000	15,000	42,000	60,000	100,000
Total Installed Cost	33,000	125,000	317,000	451,000	770,000
Engineering	6.000	20,000	49,000	69,500	115,000
Contingency	6,000	20,000	49,000	69,500	115,000
Total Capital Cost	$ 48,000	$165,000	$415,000	$590,000	$1,000,000
Land Requirement, ft^2	200	700	5,000	9,000	18,000
	Annual Operating Cost, Dollars				
Pumping	$ 140	$ 1,400	$ 7,000	$ 14,000	$ 28,000
Labor	4,000	5,000	6,000	7,000	8,000
Maintenance (3% of Capital Cost)	1,400	5,000	12,500	18,000	30,000
Total Annual Cost	$ 5,540	$ 11,400	$ 25,500	$ 39,000	$ 66,000

Note: The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-14

Granular Activated Carbon
Equipment Cost Basis
and Energy Requirements

Description	Equipment Size				
	380 m^3/day (0.1x10^6 gal/d)	3800 m^3/day (1.0x10^6 gal/d)	19,000 m^3/day (5x10^6 gal/d)	38,000 m^3/day (10x10^6 gal/d)	76,000 m^3/day (20x10^6 gal/d)
Activated Carbon Units	Three-4'diam. x 13' high	Three-11' diam. x 18' high	Nine-12' diam. x 25' high	Fifteen-12' diam. x 30' high	Thirty-12' diam. x 30' high
Carbon, ft^3 Total	281	2800	14,000	28,000	56,000
Automatic Controls Included	No	Yes	Yes	Yes	Yes
Furnace size, lb/d of carbon	N.A.	1250	6,250	12,500	25,000
			Annual Operating and Energy Requirements		
Carbon Make-up, lb/d (10% make-up)	125	125	625	1,250	2,500
Furnace Power Requirements					
Fuel, Btu/hr	N.A.	500,000	800,000	1,500,000	2,800,000
Connected hp	N.A.	40	50	60	80
Pumping Power Requirements kWh/yr	11,400	114,000	570,000	1,140,000	2,280,000
Manpower Requirements, hours	2,100	9,800	10,500	11,500	12,500

TABLE VII-15

GRANULAR ACTIVATED CARBON
CAPITAL COSTS

Description	Capital Costs, Dollars				
	380 m^3/day (0.1 X10^6) gal/d	3800 m^3/day (1.0 X10^6) gal/d	19,000 m^3/day (5 X10^6) gal/d	38,000 m^3/day (10 X10^6) gal/d	76,000 m^3/day (20 X10^6) gal/d
Activated Carbon Units	$50,000	$325,000	$1,500,000	$2,600,000	$5,000,000
Pumping & Misc. Equip. (10%)	5,000	32,500	150,000	260,000	500,000
Piping (10%)	5,000	32,500	150,000	260,000	500,000
Total Equipment Cost	60,000	390,000	1,800,000	3,120,000	6,000,000
Installation (50%)	30,000	195,000	900,000	1,560,000	3,000,000
Total Constructed Cost	90,000	585,000	2,700,000	4,680,000	9,000,000
Engineering	40,000	85,000	400,000	710,000	1,350,000
Contingency	20,000	80,000	400,000	710,000	1,350,000
Subtotal	150,000	750,000	3,500,000	6,100,000	11,700,000
Activated Carbon Regeneration System (Installed)	-----	300,000	450,000	600,000	750,000
Contingency (For utility hook-up, etc.)	-----	60,000	100,000	120,000	150,000
Engineering for Carbon Regeneration System	-----	50,000	50,000	80,000	100,000
Total Capital Cost	$150,000	$1,160,000	$4,100,000	$6,920,000	$12,700,000
Land Requirements, ft^2	300	1,500	3,500	5,500	12,000

TABLE VII-16

GRANULAR ACTIVATED CARBON
ANNUAL OPERATING COSTS

Description	Annual Costs, Dollars				
	380 m^3/day	3800 m^3/day	19,000 m^3/day	38,000 m^3/day	76,000 m^3/day
	(0.1 x10^6) gal/day	(1.0 x10^6) gal/day	(5 x10^6) gal/day	(10 x10^6) gal/day	(20 x10^6) gal/day
Carbon Make-Up	$28,000	$28,000	$137,000	$275,000	$550,000
Furnace Power	---	19,000	27,000	46,000	82,000
Pumping	500	5,000	25,000	50,000	100,000
Labor* ($10/manhour)	21,000	98,000	105,000	115,000	125,000
Maintenance (3% of total Capital Cost)	4,500	35,000	123,000	208,000	381,000
Total Annual Cost	$54,000	$185,000	$417,000	$694,000	$1,238,000

NOTE: The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

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* The manpower requirements were obtained from the "Process Design Manual for Carbon Adsorption," Environmental Protection Agency Technology Transfer Series, October 1973. Labor includes operation, maintenance, and laboratory personnel requirements.

TABLE VII-17

POWDERED ACTIVATED CARBON
EQUIPMENT COST BASES AND ENERGY REQUIREMENTS
150 mg/l DOSAGE RATE

	Equipment Size				
Description	380 m^3/d (0.1×10^6 gal/d)	3800 m^3/d (1.0×10^6 gal/d)	19,000 m^3/d (5×10^6 gal/d)	38,000 m^3/d (10×10^6 gal/d)	76,000 m^3/d (20×10^6 gal/d)
Powdered Carbon Feed Tanks (2 each) Capacity, gallons (Based on feed concentration of 1 lb carbon/gal water)	1,000	10,000	43,000	87,000	175,000
Feed Rate lb/d	125	1,250	6,250	12,500	25,000
Sludge Handling and/or Regeneration System, lb/d dry solids	335	3,350	16,700	33,500	66,700
	Annual Operating and Energy Requirements				
Carbon Make-Up lb/d (25% make-up)	125	1,250	6,250	12,500	8,350
Furnace Power Requirements					
Fuel, Btu/h	N.A.	N.A.	N.A.	N.A.	4,500,000
Connected hp	N.A.	N.A.	N.A.	N.A.	140
Manpower Requirements, hours	400	540	940	1,240	10,700

TABLE VII-18

POWDERED ACTIVATED CARBON
CAPITAL COSTS
150 mg/l DOSAGE RATE

Description	Capital Costs, Dollars 380 m^3/d $(0.1x10^6$ gal/d)	3800 m^3/d $(1.0x10^6$ gal/d)	19,000 m^3/d $(5x10^6$ gal/d)	38,000 m^3/d $(10x10^6$ gal/d)	76,000 m^3/d $(20x10^6$ gal/d)
Powdered Carbon Feed System	$15,000	$45,000	$65,000	$90,000	$150,000
Solids Dewatering System	--	--	--	--	615,000
Regenerated Carbon Acid Wash System	--	--	--	--	60,000
Subtotal	15,000	45,000	65,000	90,000	825,000
Piping (10%)	1,500	4,500	6,500	9,000	83,000
Total Equipment Cost	16,500	49,500	71,500	99,000	908,000
Installation (50%)	8,500	24,500	35,500	49,500	454,000
Total Constructed Cost	25,000	74,000	107,000	148,500	1,362,000
Engineering	9,000	13.000	16,500	22,250	207,500
Contingency	9,000	13,000	16,500	22,250	207,500
Subtotal	43,000	100,000	140,000	193,000	1,777,000
Activated Carbon Regeneration System (Installed)	--	--	--	--	1,300,000
Contingency (For Utility Hook-up, etc.)	--	--	--	--	280,000
Engineering for Carbon Regeneration System	--	--	--	--	200,000
Total Capital Cost	$ 43,000	$ 100,000	$140,000	$193,000	$3,557,000
Land Requirements, ft^2	100	800	2,000	3,000	4,500

TABLE VII-19

POWDERED ACTIVATED CARBON
ANNUAL OPERATING COSTS
150 mg/l DOSAGE RATE

	Annual Cost, Dollars				
Description	380 m^3/d (0.1x10^6 gal/d)	3800 m^3/d (1.0x10^6 gal/d)	19,000 m^3/d (5x10^6 gal/d)	38,000 m^3/d (10x10^6 gal/d)	76,000 m^3/d (20x10^6 gal/d)
Carbon Make-Up	$13,900	$139,000	$694,000	$1,388,000	$ 825,000
Furnace Power	--	--	--	--	132,000
Miscellaneous Power Requirements	1,000.	2,000	5,000	8,000	15,000
Labor ($10/man-hour)	4,000	5,400	9,400	12,400	108,000
Maintenance	1,000	2,000	3,000	4,000	491,000
Total Annual Cost	$19,900	$148,400	$711,400	$1,412,400	$1,571,000

Note:

The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-20

PACT
COMPARISON OF OPERATING COSTS
CARBON REGENERATION VS. THROW-AWAY
150 mg/l DOSAGE RATE

			Regenerated		
Description	380 m^3/d ($0.1x10^6$ gal/d)	3800 m^3/d ($1.0x10^6$ gal/d)	19,000 m^3/d ($5x10^6$ gal/d)	38,000 m^3/d ($10x10^6$ gal/d)	76,000 m^3/d ($20x10^6$ gal/d)
Capital Cost	$743,000	$1,035,000	$1,743,000	$2,463,000	$3,557,000
Carbon Make-up	4,130	41,300	207,000	413,000	825,000
Furnace Power	5,000	19,000	44,000	76,000	132,000
Miscellaneous Power	1,000	2,000	5,000	8,000	15,000
Labor	91,600	93,000	97,000	100,000	108,000
Maintenance (3%)	1,000	2,000	3,000	4,000	6,000
(15%)	105,000	140,000	240,000	343,000	485,000
Depreciation (25%)	200,000	280,000	471,000	665,000	961,000
Total Annual Cost	$407,730	$577,300	$1,067,000	$1,609,000	$2,532,000
			Non-Regenerated		
Capital Cost	$ 43,000	$100,000	$140,000	$193,000	$322,000
Carbon Make-up	13,900	139,000	694,000	1,388,000	2,775,000
Labor	4,000	5,400	9,400	12,400	19,400
Maintenance (3%)	1,000	2,000	3,000	4,000	6,600
Miscellaneous Power	1,000	2,000	5,000	8,000	15,000
Depreciation (27%)	11,600	27,000	37,800	52,100	87,000
Total Annual Cost	$ 31,500	$175,400	$749,200	$1,464,500	$2,903,000
Cost for Sludge Dewatering	25,000	95,000	171,000	282,000	419,000
Annual Cost with Sludge Dewatering	$ 56,500	$270,400	$920,200	$1,746,500	$3,322,000
Cost for Land Disposal	5,000	50,000	250,000	500,000	1,000,000
Annual Cost with Land Disposal	$ 61,500	$320,400	$1,170,200	$2,246,500	$4,322,000

TABLE VII-21

POWDERED ACTIVATED CARBON
EQUIPMENT COST BASES AND ENERGY REQUIREMENTS
INCLUDING COSTS FOR SLUDGE DISPOSAL
150 mg/l DOSAGE RATE

	Equipment Size				
Description	380 m^3/d (0.1x10^6 gal/d)	3800 m^3/d (1.0x10^6 gal/d)	19,000 m^3/d (5x10^6 gal/d)	38,000 m^3/d (10x10^6 gal/d)	76,000 m^3/d (20x10^6 gal/d)
Powdered Carbon Feed Tanks (2 each) Capacity, gallons (Based on feed concentration of 1 lb carbon/gal water)	1,000	10,000	43,000	87,000	175,000
Feed Rate lb/d	125	1,250	6,250	12,500	25,000
Sludge handling and/or Regeneration System, lb/d dry solids	335	3,350	16,700	33,500	66,700
Annual Operating and Energy Requirements					
Carbon Make-Up lb/d (25% make-up)	125	1,250	2,100	418	8,350
Furnace Power Requirements					
Fuel, Btu/h	N.A.	N.A.	1,300,000	2,500,000	4,500,000
Connected hp	N.A.	N.A.	80	100	140
Manpower Requirements, hours	400	540	9,700	10,000	10,700

TABLE VII-22

POWDERED ACTIVATED CARBON
CAPITAL COSTS
INCLUDING COSTS FOR SLUDGE DISPOSAL
150 mg/l DOSAGE RATE

Description	Capital Costs, Dollars 380 m^3/d ($0.1x10^6$ gal/d)	3800 m^3/d ($1.0x10^6$ gal/d)	19,000 m^3/d ($5x10^6$ gal/d)	38,000 m^3/d ($10x10^6$ gal/d)	76,000 m^3/d ($20x10^6$ gal/d)
Powdered Carbon Feed System	$15,000	$ 45,000	$ 65,000	$ 90,000	$150,000
Solids Dewatering System	--	--	250,000	415,000	615,000
Regenerated Carbon Acid Wash System	--	--	20,000	40,000	60,000
Subtotal	15,000	45,000	335,000	545,000	825,000
Piping (10%)	1,500	4,500	34,000	55,000	83,000
Total Equipment Cost	16,500	49,500	369,000	602,000	908,000
Installation (50)	8,500	24,500	185,000	300,000	454,000
Total Constructed Cost	25,000	74,000	554,000	900,000	1,362,000
Engineering	9,000	13,000	82,000	131,500	207,500
Contingency	9,000	13,000	82,000	131,500	207,500
Subtotal	43,000	100,000	718,000	1,163,000	1,777,000
Activated Carbon Regeneration System (Installed)	--	--	750,000	950,000	1,300,000
Contingency (For Utility Hook-up, etc.)	--	--	160,000	200,000	280,000
Engineering for Carbon Regeneration System	--	--	115,000	150,000	200,000
Total Capital Cost	$43,000	$100,000	$1,743,000	$2,463,000	$3,557,000
Land Requirements, ft^2	100	800	2,000	3,000	4,500

TABLE VII-23

POWDERED ACTIVATED CARBON
ANNUAL OPERATING COSTS
INCLUDING CREDIT FOR SLUDGE DISPOSAL
150 mg/l DOSAGE RATE

	Annual Cost, Dollars				
Description	380 m^3/d (0.1×10^6 gal/d)	3800 m^3/d (1.0×10^6 gal/d)	19,000 m^3/d (5×10^6 gal/d)	38,000 m^3/d (10×10^6 gal/d)	76,000 m^3/d (20×10^6 gal/d)
Carbon Make-up	$13,900	$139,000	$207,000	$413,000	$825,000
Furnace Power	--	--	55,000	95,000	165,000
Miscellaneous Power Requirements	1,000	2,000	5,000	8,000	15,000
Labor ($10/man-hour)	4,000	5,400	97,000	100,000	108,000
Sludge Disposal Credit	--	--	(-)250,000	(-)500,000	(-)1,000,000
Maintenance	1,000	2,000	243,000	347,000	491,000
Total Annual Cost	$19,900	$148,400	$357,000	$463,000	$604,000

Note:

The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement

TABLE VII-24

SUPPLEMENTAL ECONOMIC COST INFORMATION
CAPITAL AND OPERATING COSTS
FOR 10,000 GALLON PER DAY TREATMENT SYSTEMS

Treatment System	Capital Cost, Dollars	Annual Operating Cost Dollars*
Equalization	$ 12,000	$ 400
Rotating Biological Contactors	50,000	6,100
Filtration	35,000	3,000
Powdered Activated Carbon	35,000	4,300
Granular Carbon	60,000	10,000

Note: The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-25

COOLING TOWER BLOWDOWN RATES
PETROLEUM REFINING INDUSTRY
(MILLION GALLONS PER DAY)

REFINERY NUMBER	BLOWDOWN	REFINERY NUMBER	BLOWDOWN	REFINERY NUMBER	BLOWDOWN
1	0.008000	57	6.300000	110	NOT APP.
2	0.014400	58	0.268600	111	1.106499
3	UNKNOWN	59	50.167191	112	UNKNOWN
4	NOT APP.	60	0.850250	113	0.109000
6	NOT APP.	61	1.400000	114	0.128000
7	0.030000	62	1.024999	115	0.520600
8	UNKNOWN	63	0.298500	116	0.288000
9	0.001440	64	1.000999	117	0.500000
10	0.015000	65	0.943500	118	0.011500
11	1.794998	66	UNKNOWN	119	0.031000
12	0.002000	67	3.229999	120	0.022500
13	1.014999	68	2.447998	121	0.740000
15	0.028200	70	UNKNOWN	122	1.562500
16	0.069300	71	0.095500	124	0.135000
17	0.005000	72	0.022000	125	0.113500
18	0.021440	73	0.138200	126	0.120000
19	0.001500	74	0.157000	127	0.025000
20	0.320000	76	0.826000	128	NOT APP.
21	0.011250	77	0.198000	129	0.066600
22	0.010500	78	0.015000	130	NOT APP.
23	NOT APP.	79	0.0	131	0.120000
24	0.065000	80	0.870000	132	0.750000
25	0.167000	81	0.242000	133	1.830997
26	0.074500	82	6.000000	134	UNKNOWN
29	0.330000	83	1.014999	135	UNKNOWN
30	0.033200	84	UNKNOWN	136	0.0
31	10.000000	85	2.539797	137	0.0
32	0.840000	86	0.147700	138	0.153000
33	0.110000	87	NOT APP.	139	0.006000
35	NOT APP.	88	0.072500	140	0.055500
36	0.005500	89	UNKNOWN	141	0.0
37	1.834998	90	0.007000	142	0.110000
38	0.702000	91	0.003600	143	UNKNOWN
39	0.060000	92	2.023998	144	0.143500
40	UNKNOWN	93	0.021040	145	UNKNOWN
41	1.013998	94	0.432000	146	UNKNOWN
42	0.012000	95	UNKNOWN	147	0.490000
43	0.550000	96	6.011999	148	0.055000
44	UNKNOWN	97	0.008354	149	0.150000
45	0.816999	98	0.775000	150	NOT APP.
46	0.145000	99	NOT APP.	151	1.504999
48	0.141000	100	NOT APP.	152	1.779999
49	0.170000	102	UNKNOWN	153	3.806998
50	0.025500	103	0.005000	154	0.050000
51	NOT APP.	104	2.589997	155	34.663391
52	NOT APP.	105	NOT APP.	156	0.564000
53	0.035500	106	0.524000	157	0.925000
54	UNKNOWN	107	0.010000	158	0.066710
55	NOT APP.	108	UNKNOWN	159	0.066000
56	0.650000	109	0.185000	160	0.042000

TABLE VII-25 (Continued)

COOLING TOWER BLOWDOWN RATES
PETROLEUM REFINING INDUSTRY
(MILLION GALLONS PER DAY)

REFINERY NUMBER	BLOWDOWN	REFINERY NUMBER	BLOWDOWN	REFINERY NUMBER	BLOWDOWN
161	1.128999	202	UNKNOWN	241	0.109500
162	0.356250	203	2.034996	242	0.305000
163	0.641500	204	1.536595	243	0.125000
164	0.015000	205	0.345550	244	31.500000
165	0.168000	206	2.500000	245	0.931000
166	0.025000	207	0.036500	246	0.042500
167	1.189999	208	0.859999	247	0.556700
168	0.620000	209	0.095000	248	UNKNOWN
169	1.659999	210	0.014500	249	0.015000
172	0.149000	211	0.279100	250	UNKNOWN
173	UNKNOWN	212	0.374000	251	NOT APP.
174	NOT APP.	213	0.012960	252	0.001500
175	4.360797	214	UNKNOWN	253	UNKNOWN
176	0.002600	215	UNKNOWN	254	UNKNOWN
177	0.014000	216	2.420487	255	UNKNOWN
179	0.149200	218	1.000000	256	0.000800
180	0.386000	219	0.565000	257	NOT APP.
181	5.218994	220	0.012000	258	0.633500
182	1.858498	221	UNKNOWN	259	NOT APP.
183	0.340650	222	0.200000	260	NOT APP.
184	0.521320	224	UNKNOWN	261	0.200000
185	0.322000	225	0.711000	264	UNKNOWN
186	0.515399	226	UNKNOWN	265	0.259000
187	0.983000	227	0.388500	266	NOT APP.
188	1.005500	228	0.122000	278	UNKNOWN
189	> 0.0	229	0.008500	291	1.259999
190	0.005000	230	0.370000	292	NOT APP.
191	0.485000	231	NOT APP.	295	0.158000
192	0.011000	232	UNKNOWN	296	NOT APP.
193	UNKNOWN	233	0.307000	298	> 0.0
194	2.987994	234	UNKNOWN	302	NOT APP.
195	UNKNOWN	235	0.230000	303	UNKNOWN
196	3.507991	236	> 0.0	305	0.010000
197	0.000500	237	0.750000	307	UNKNOWN
199	0.006500	238	0.325000	308	> 0.0
200	0.395000	239	UNKNOWN	309	0.302000
201	0.483000	240	0.072000		

> - DUE TO UNKNOWN VALUES IN ONE OF THE COOLING TOWERS, THE VALUE IS GREATER THAN SHOWN

NOT APP. - DUE TO A ZERO RESPONSE TO PERCENT COOLING BY COOLING TOWERS

TABLE VII-26

Chromium Removal Systems
Equipment Cost Basis and Energy Requirements

Description	3.8 m^3/day (1×10^3 gal/d)	38 m^3/day (1×10^4 gal/d)	380 m^3/day (1×10^5 gal/d)	3800 m^3/day (1×10^6 gal/d)	19,000 m^3/day (5×10^6 gal/d)
Detention Tank, gallons	32	320	3,200	32,000	160,000
Mixer, hp	0.25	0.25	1.5	15	80
Mixing Requirements, kWh/yr	1,650	1,650	9,900	99,000	528,000
Solids Contact Clarifier, diam	8	8	15	45	100
SO_2 Feed Rate, lb/d	0.4	4	40	400	2,000
Acid Feed Rate, lb/d	0.2	2	20	200	1,000
Caustic Feed Rate, lb/d	2	20	200	2,000	10,000
Pumping Requirements, kWh/yr	23	230	2,300	23,000	115,000
Manpower Requirements, h/yr	520	520	520	1,040	2,080

TABLE VII-27

Chromium Removal Systems
Capital and Operating Costs

Description	3.8 m^3/day (1x10^3 gal/day)	38 m^3/day (1x10^4 gal/day)	380 m^3/day (1x10^5 gal/day)	3800 m^3/day (1x10^6 gal/day)	19,000 m^3/day (5x10^6 gal/day)
			Capital Costs, Dollars		
Detention Tank	\$ 100	\$ 1,000	\$ 5,000	\$20,000	\$50,000
Chemical Feed Systems	5,000	15,000	30,000	40,000	45,000
Automatic Controls	--	10,000	10,000	10,000	10,000
Solids Contact Clarifier Pumps	25,000	25,000	35,000	80,000	155,000
Total Equipment Cost	30,100	51,000	80,000	150,000	260,000
Installation (50%)	15,000	25,500	40,000	75,000	130,000
Total Constructed Cost	45,100	76,500	120,000	225,000	390,000
Engineering	6,950	11,750	17,500	37,500	60,000
Contingency	6,950	11,750	17,500	37,500	60,000
Total Capital Cost	\$59,000	\$100,000	\$155,000	\$300,000	\$510,000
			Annual Operating Costs, Dollars*		
SO_2	\$ 16	\$ 160	\$ 1,600	\$ 16,000	\$ 80,000
Acid	4	40	400	4,000	20,000
Caustic	130	1,300	13,000	130,000	620,000
Mixing	70	70	400	4,000	21,000
Pumping	Negligable	10	100	1,000	5,000
Labor	5,200	5,200	5,200	10,000	20,000
Maintenance (3% of Total Capital Cost)	1,780	3,000	4,800	9,000	16,000
Total Annual Cost	\$ 7,200	\$ 9,780	\$ 25,500	\$174,000	\$782,000

*Note: The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE VII-28

Wastewater Recycle - Capital and Operating Costs

	Capital Costs, Dollars - Per Mile					
Description	2.3 m^3/hr (10 gpm)	16 m^3/hr (70 gpm)	80 m^3/hr (350 gpm)	160 m^3/hr (700 gpm)	320 m^3/hr (1400 gpm)	800 m^3/hr (3500 gpm)
Piping:						
Piping, installed, per mile	$32,000	$53,000	$100,000	$135,000	$175,000	$243,000
Misc. Costs (15%)	5,000	8,000	15,000	20,000	26,000	36,000
Total Constructed cost, per mile	37,000	61,000	115,000	155,000	201,000	279,000
Engineering (15%)	6,000	9,000	18,000	23,000	30,000	42,000
Contingency	7,000	10,000	17,000	22,000	29,000	42,000
Piping-total capital costs per mile	$50,000	$80,000	$150,000	$200,000	$260,000	$363,000
Pumps:						
Pumps and associated equipment installed (10% of piping cost)	5,000	8,000	15,000	20,000	26,000	37,000
Total capital costs per mile	$55,000	$88,000	$165,000	$220,000	$286,000	$400,000
(Minimum pumping costs regardless of distance)	5,000	6,000	12,000	18,000	24,000	40,000
	Annual Operating Costs, Dollars - Per Mile					
Pumping costs per mile, per year	$100	$ 700	$2600	$4500	$ 9200	$24,300
Maintenance (1.5% of capital costs) per mile, per year	800	1300	2500	3300	4300	6,000
Total Annual operating cost	$900	$2000	$5100	$7800	$13,500	$30,300

Note: The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Input Analysis Supplement.

TABLE VII-29

Water Softening of Recycled Wastewater

Description	Capital Costs, Dollars					
	2.3 m^3/hr (10 gpm)	16 m^3/hr (70 gpm)	80 m^3/hr (350 gpm)	160 m^3/hr (700 gpm)	320 m^3/hr (1400 gpm)	800 m^3/hr (3500 gpm)
Solids Contact Clarifier	$ 25,000	$ 30,000	$ 45,000	$ 65,000	$ 80,000	$125,000
(Diameter, ft)	(8)	(11)	(23)	(32)	(45)	(72)
Chemical Feed System(s)	5,000	7,000	10,000	15,000	25,000	50,000
Filter Unit	15,000	25,000	30,000	40,000	80,000	150,000
(Diameter, ft)	(3)	(8)	(11)	(15)	(two-15' units)	(three-20' units)
Subtotal	45,000	62,000	85,000	120,000	185,000	325,000
Auxiliary Equipment	5,000	8,000	10,000	15,000	20,000	35,000
Total Capital Cost	50,000	70,000	95,000	135,000	205,000	360,000
Installation(50%)	25,000	35,000	50,000	70,000	100,000	180,000
Total Constructed Cost	75,000	105,000	145,000	205,000	305,000	540,000
Engineering	15,000	20,000	25,000	30,000	45,000	80,000
Contingency	15,000	20,000	25,000	30,000	45,000	80,000
Total Capital Costs	$105,000	$145,000	$195,000	$265,000	$395,000	$700,000

TABLE VII-30

CAPITAL AND OPERATING COSTS BY REFINERY NUMBER
ECONOMIC COSTS, DOLLARS

REFINERY NUMBER	OPTION 2 Level 1		OPTION 2 LEVEL 2	
	Capital Costs	Annual Operating Costs	Capital Costs	Annual Operating Costs
1	0	0	50,000	21,500
2	0	0	50,000	9,000
3	0	0	35,000	5,000
6	0	0	85,000	8,000
7	0	0	70,000	7,000
9	0	0	52,000	6,200
10	0	0	70,000	7,000
11	0	0	60,000	67,000
12	0	0	441,000	27,000
13	No cost - considered presently indirect discharger only			
19	No cost - insignificant flow			
20	0	0	75,000	150,000
24	0	0	240,000	16,000
30	180,000	10,500	230,000	34,500
32	0	0	4,000,000	192,000
37	0	0	1,600,000	84,000
38	No cost - considered presently indirect discharger only			
40	435,000	17,975	555,000	528,000
41	0	0	6,400,000	290,000
43	0	0	2,100,000	102,000
46	0	0	60,000	73,000
49	0	0	120,000	10,000
50	0	0	565,000	34,000
51	865,000	567,000	3,140,000	904,000
52	0	0	240,000	16,000
53	0	0	35,000	18,000
54	0	0	35,000	11,000
56	195,000	14,300	1,100,000	62,000
57	530,000	91,000	630,000	653,000
59	0	0	75,000	84,900
60	0	0	75,000	145,000
61	0	0	80,000	105,000
62	0	0	100,000	373,000
63	0	0	1,900,000	49,000
64	235,000	16,000	310,000	209,000
65	370,000	27,000	470,000	309,000
67	1,610,000	275,000	5,860,000	635,000
68	385,000	39,000	485,000	415,000
70	12,500	8,500	160,000	26,500

TABLE VII-30 (Cont.)

CAPITAL AND OPERATING COSTS BY REFINERY NUMBER
ECONOMIC COSTS, DOLLARS

REFINERY NUMBER	OPTION 2 Level 1		OPTION 2 LEVEL 2	
	Capital Costs	Annual Operating Costs	Capital Costs	Annual Operating Costs
71	0	0	200,000	15,000
72	0	0	35,000	17,000
73	No Cost - Will Discharge to POTW in Future			
74	0	0	170,000	13,000
76	180,000	11,400	1,430,000	77,400
77	0	0	40,000	28,000
80	0	0	90,000	9,000
81	160,000	9,100	1,040,000	57,100
83	0	0	85,000	192,000
84	0	0	75,000	139,000
85	0	0	95,000	264,000
87	125,000	8,400	220,000	17,400
88	0	0	175,000	13,000
89	0	0	77,000	9,000
90	0	0	60,000	7,000
91	0	0	35,000	4,000
92	480,000	30,900	2,810,000	367,000
93	0	0	35,000	6,000
94	228,000	12,400	303,000	157,000
96	0	0	2,480,000	343,000
97	0	0	35,000	11,000
98	0	0	1,600,000	80,000
99	0	0	83,000	8,000
100	0	0	35,000	9,500
102	230,000	13,600	305,000	32,600
103	0	0	78,000	8,000
104	0	0	4,100,000	180,000
105	305,000	22,200	380,000	203,000
106	0	0	1,100,000	60,000
107	No Cost - Will Discharge to POTW in Future			
108	0	0	35,000	8,000
109	0	0	40,000	25,000
110	No Cost - Will Discharge to POTW in Future			
112	160,000	9,700	330,000	22,700
113	0	0	330,000	21,000
114	No Cost - Will Discharge to POTW in Future			
115	0	0	90,000	216,000
116	0	0	900,000	48,000
117	355,000	8,600	945,000	42,600

TABLE VII-30 (Cont.)

REFINERY NUMBER	OPTION 2 Level 1		OPTION 2 LEVEL 2	
	Capital Costs	Annual Operating Costs	Capital Costs	Annual Operating Costs
118	0	0	55,000	6,500
119	0	0	115,000	10,000
120	0	0	100,000	9,000
121	0	0	3,100,000	151,000
122	520,000	83,500	4,920,000	288,000
124	0	0	365,000	23,000
125	0	0	340,000	21,500
126	260,000	25,200	4,660,000	236,000
127	0	0	150,000	12,000
129	120,000	8,300	220,000	17,300
131	0	0	90,000	236,000
132	740,000	108,000	3,070,000	454,000
133	660,000	135,000	785,000	735,000
134	350,000	34,000	450,000	348,000
142	No cost - will discharge to POTW in future			
143	No cost - will discharge to POTW in future			
144	0	0	113,000	10,000
146	125,000	8,300	220,000	17,300
147	0	0	40,000	51,100
149	170,000	11,400	970,000	53,400
150	0	0	52,000	81,000
151	330,000	18,500	3,030.000	151,000
152	630,000	118,000	745,000	730,000
153	0	0	100,000	300,000
154	0	0	700,000	40,000
155	0	0	95,000	9,000
156	0	0	475,000	28,500
157	0	0	75,000	161,000
158	0	0	40,000	49,000
159	0	0	225,000	15,500
160	0	0	35,000	20,500
161	0	0	275,000	18,000
162	0	0	75,000	198,000
163	0	0	700,000	42,000
165	0	0	234,000	16,100
167	575,000	59,000	675,000	455,000
168	0	0	80,000	228,000
169	720,000	96,300	845,000	765,000
172	185,000	14,100	23,500	79,100
173	160,000	9,700	200,000	52,700

TABLE VII-30 (Cont.)

REFINERY NUMBER	OPTION 2 Level 1		OPTION 2 LEVEL 2	
	Capital Costs	Annual Operating Costs	Capital Costs	Annual Operating Costs
174	135,000	8,300	565,000	34,300
175	No cost - will discharge to POTW in future			
176	0	0	285,000	19,000
177	175,000	12,300	225,000	77,300
179	0	0	225,000	15,800
180	315,000	28,100	390,000	245,000
181	980,000	106,000	3,540,000	448,000
183	0	0	420,000	24,900
184	0	0	75,000	100,000
186	0	0	75,000	146,000
189	0	0	53,000	6,200
190	0	0	60,000	6,400
194	750,000	44,500	10,100,000	541,000
196	1,280,000	193,000	4,380,000	549,000
197	0	0	50,000	6,000
199	125,000	8,300	197,000	15,300
201	0	0	60,000	80,000
204	268,000	18,700	358,000	283,000
205	270,000	16,400	1,970,000	101,000
208	0	0	100,000	390,000
210	0	0	35,000	5,000
211	0	0	60,000	69,000
212	0	0	50,000	61,000
213	0	0	73,000	7,000
216	0	0	3,250,000	358,000
219	0	0	850,000	48,000
221	300,000	22,300	390,000	281,000
222	155,000	9,800	430,000	27,800
226	0	0	65,000	7,000
227	0	0	60,000	96,000
230	0	0	520,000	31,000
231	No cost - will discharge to POTW in future			
232	0	0	60,000	90,000
233	0	0	60,000	85,000
234	0	0	60,000	85,000
235	0	0	75,000	120,000
236	0	0	35,000	13,000
237	0	0	35,000	6,000
238	243,000	17,500	318,000	168,000

TABLE VII-30 (Cont.)

REFINERY NUMBER	OPTION 2 Level 1		OPTION 2 LEVEL 2	
	Capital Costs	Annual Operating Costs	Capital Costs	Annual Operating Costs
239	0	0	35,000	16,500
240	0	0	40,000	24,500
241	0	0	45,000	40,000
242	0	0	40,000	28,000
243	0	0	145,000	11,500
252	0	0	115,000	10,000
255	0	0	115,000	10,000
256	0	0	285,000	19,000
257	0	0	1,400,000	72,000
258	0	0	60,000	84,000
259	0	0	75,000	169,000
260	0	0	58,000	6,300
261	180,000	10,300	228,000	50,300
265	0	0	48,000	51,000
266	130,000	8,300	190,000	66,300
292	No cost - insignificant flow			
295	170,000	10,800	210,000	35,800
309	220,000	473,000	265,000	513,000

TABLE VII-31

CAPITAL AND OPERATING COSTS

INDIRECT DISCHARGE - OPTION 1

Refinery Code No.	Cooling Tower Blowdown gal/day	Chromium Removal, $ Capital Cost	Chromium Removal, $ Annual Operating Cost	Piping Cost, $ Capital Cost	Piping Cost, $ Annual Operating Cost	Total Cost, $ Capital Cost	Total Cost, $ Annual Operating Cost
8	1,250**	63,000	7,300	*	*	63,000	7,300
13	1,020,000	300,000	175,000	320,000	11,000	620,000	186,000
14	7,700	94,000	8,000	20,000	400	114,000	8,400
16	69,300	143,000	20,000	45,000	900	188,000	20,900
18	21,500	115,000	12,500	30,000	400	145,000	12,900
21	11,300	102,000	10,000	*	*	102,000	10,000
23	Does Not Have Cooling Tower +						
25	167,000	172,000	40,000	60,000	1,600	232,000	41,600
29	325,000	207,000	70,000	150,000	4,200	357,000	74,200
31	10,000	100,000	9,800	*	*	100,000	9,800
33	110,000	156,000	28,000	50,000	1,100	206,000	29,100
38	702,000	265,000	130,000	160,000	5,000	425,000	135,000
45	817,000	280,000	150,000	200,000	6,500	480,000	157,000
58	269,000	194,000	60,000	90,000	2,500	284,000	62,500
73	139,000	165,000	35,000	60,000	1,300	225,000	36,300
78	15,000	108,000	10,000	35,000	500	143,000	10,500

TABLE VII-31 (Cont.)

Refinery Code No.	Cooling Tower Blowdown gal/day	Chromium Removal, $		Piping Cost, $		Total Cost, $	
		Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost
78	15,000	108,000	10,000	35,000	500	143,000	10,500
79	No Cost - Unknown Flow					211,000	36,100
86	148,000	166,000	35,000	45,000	1,100		
107	10,000	100,000	10,000	*	*	100,000	10,000
110	No Cooling Tower +						
111	1,110,000	310,000	188,000	160,000	5,600	470,000	194,000
114	Non Chromium Treatment ++						
128	No Cooling Tower +						
130	No Cooling Tower +						
142	110,000	156,000	28,000	60,000	1,400	216,000	29.400
143	Non Chromium Treatment ++						
145	1,000**	59,000	7,200	*	*	59,000	7,200
148	Non Chromium Treatment ++						
166	25,000	118,000	12,000	*	*	118,000	12,000
175	4,360,000	487,000	628,000	485,000	34,200	972,000	662,000
182	1,860,000	370,000	285,000	630,000	28,700	1,000,000	314,000
188	1,010,000	300,000	175,000	200,000	7,000	500,000	182,000

TABLE VII-31 (Cont.)

Refinery Code No.	Cooling Tower Blowdown gal/day	Chromium Removal, $		Piping Cost, $		Total Cost, $	
		Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost
193	130**	59,000	7,200	*	*	59,000	7,200
195	No Cooling Tower +						
200	395,000	220,000	80,000	65,000	2,000	285,000	82,000
203	2,040,000	382,000	308,000	680,000	31,800	1,062,000	340,000
206	2,000	70,000	8,000	*	*	70,000	8,000
207	36,500	126,000	15,000	40,000	700	166,000	15,700
220	Non Chromium Treatment ++						
224	Non Chromium Treatment ++						
225	Non Chromium Treatment ++						
228	122,000	166,000	30,000	50,000	1,000	216,000	31,000
229	8,500	98,000	9,400	*	*	98,000	9,400
231	No Cooling Towers +						
264	No Cooling Towers +						
291	126,000	162,000	30,000	40,000	800	202,000	30,800
305	11,600**	103,000	11,300	*	*	103,000	11,300
TOTAL		5,916,000	2,633,000	3,675,000	150,000	9,591,000	2,783,000

TABLE VII-31 (Cont.)

NOTE:

* These Refineries have only one cooling tower and so piping cost is excluded.

** Actual Cooling Tower blowdown data were not available; the blowdown rate is assumed to be 25% of total wastewater generated.

+ These Refineries do not have any cooling towers.

++ These Refineries do not use Chromium in the cooling towers.

TABLE VII-32

CAPITAL AND OPERATING COSTS

INDIRECT DISCHARGE - OPTION 2

Refinery Code No.	Capital Costs, $	Annual Operating Costs, $
8	No Cost - Insignificant Flow	
13	5,800,000	626,000
14	315,000	51,400
16	826,000	136,000
18	495,000	58,000
21	373,000	62,500
23	315,000	60,200
25	375,000	54,500
29	4,650,000	521,000
31	247,000	54,700
33	1,090,000	152,000
38	4,350,000	455,000
45	3,900,000	419,000
58	1,900,000	159,000
73	915,000	84,100
78	1,390,000	119,000
79	No Cost - Unknown Flow	
86	800,000	104,000
107	255,000	57,900
110	250,000	56,700
111	2,450,000	211,000
114	683,000	103,000
128	277,000	29,700
130	1,310,000	421,000

TABLE VII-32 - Continued

Refinery Code No.	Capital Costs, $	Annual Operating Costs, $
142	2,450,000	211,000
143	2,190,000	174,000
145	247,000	54,700
148	493,000	111,000
166	273,000	96,900
175	13,300,000	2,360,000
182	7,000,000	781,000
188	3,660,000	340,000
193	247,000	54,700
195	247,000	54,700
200	1,150,000	106,000
203	13,800,000	1,510,000
206	437,000	95,800
207	375,000	92,500
220	258,000	56,700
224	655,000	112,000
225	2,220,000	177,000
228	710,000	112,000
229	242,000	25,400
231	1,110,000	378,000
264	250,000	55,500
291	250,000	51,200
305	277,000	29,700

TABLE VII-33

EFFECTIVENESS OF BAT OPTIONS FOR DIRECT DISCHARGERS
POUNDS REMOVED FROM BPT TO LEVEL 1

Refinery No.	BOD	TSS	Oil & Grease	Chromium (Hex.)	Chromium (Total)	Phenol
1	67	56	21	.074	1.12	1.29
2	27	22	8	.030	0.45	0.33
3	12	10	4	.013	0.20	0.14
6	32	26	10	.035	0.53	0.80
7	58	48	18	.064	0.97	0.64
9	4	4	1	.004	0.07	0.10
10	33	27	10	.036	0.55	0.58
11	213	175	67	.234	3.55	3.41
12	24	20	8	.026	0.40	0.49
19	22	19	7	.024	0.37	1.33
20	344	283	108	.378	5.73	5.84
24	101	83	32	.111	1.68	1.05
30	49	41	16	.054	0.82	0.40
32	502	414	158	.551	8.37	7.06
37	560	461	176	.615	9.33	10.05
40	970	799	304	1.065	16.17	13.81
41	1720	1417	540	1.889	28.67	25.29
43	390	321	122	.428	6.50	5.37
46	502	414	158	.551	8.37	6.74
49	2	1	0	.002	0.03	1.08
50	0	0	0	.000	0.00	0.00
51	741	610	232	.814	12.35	9.42
52	0	0	0	.000	0.00	0.00
53	50	41	16	.055	0.83	0.82
54	5	4	1	.005	0.08	0.12
56	0	0	0	.000	0.00	0.00
57	116	95	36	.127	1.93	4.08
59	104	85	32	.114	1.73	2.29
60	553	456	174	.607	9.22	7.67
61	659	542	207	.724	10.98	9.58
62	3250	2677	1020	3.569	54.17	34.30
63	67	56	21	.074	1.17	3.54
64	267	220	84	.293	4.45	4.19
65	502	414	158	.551	8.37	6.85
67	2400	1976	753	2.635	40.00	28.42
68	0	0	0	.000	0.00	0.00
70	19	16	6	.021	0.32	0.22
71	0	0	0	.000	0.00	0.00
72	41	33	13	.045	0.68	0.55
74	36	30	11	.040	0.60	1.10
76	337	278	106	.370	5.62	4.09
77	0	0	0	.000	0.00	0.00
80	55	46	17	.060	0.92	2.11
81	114	94	36	.125	1.90	1.98
83	271	224	85	.298	4.52	5.62
84	36	30	11	.040	0.60	1.98
85	336	277	105	.369	5.60	6.47
87	11	9	3	.012	0.18	0.09
88	75	62	24	.082	1.25	0.77
89	13	11	4	.014	0.22	0.17
90	1	1	0	.001	0.02	0.23
91	9	7	3	.010	0.15	0.07
92	3030	2495	951	3.327	50.50	31.49
93	12	10	4	.013	0.20	0.11
94	108	89	34	.119	1.80	2.58
96	3050	2511	957	3.349	[illegible]	36.64
97	9	7	3	.010	[illegible]	1.10
98	491	404	154	.539	[illegible]	7.80
99	9	7	3	.010	0.15	0.67
100	16	14	5	.018	0.27	0.18
102	130	107	41	.143	2.17	1.93
.03	55	46	17	.060	0.92	0.61
.04	890	733	279	.977	14.83	15.17
105	4	4	1	.004	0.07	2.15
106	262	216	82	.288	4.37	7.08
108	100	83	32	.110	1.67	1.54
109	0	0	0	.000	0.00	0.00
112	24	20	8	.026	0.40	0.22
113	86	70	27	.094	1.43	1.32
115	1043	859	327	1.145	17.38	9.80
116	311	256	97	.341	5.18	4.28
117	86	70	27	.094	1.43	1.15
118	71	58	22	.078	1.18	0.69
119	122	100	38	.134	2.03	1.14
120	46	38	15	.051	0.77	0.49
121	793	653	249	.871	13.22	10.18

TABLE VII-33 - Continued

Refinery No.	BOD	TSS	Oil & Grease	Chromium (Hex.)	Chromium (Total)	Phenol
122	644	530	202	.707	10.73	6.59
124	144	119	45	.158	2.40	1.92
125	155	127	48	.170	2.58	2.00
126	48	40	15	.053	0.80	1.97
127	4	4	1	.004	0.07	0.33
129	0	0	0	.000	0.00	0.00
131	629	518	197	.691	10.48	8.14
132	810	667	254	.889	13.50	15.17
133	660	544	207	.725	11.00	7.75
134	18	15	6	.020	0.30	3.81
144	0	0	0	.000	0.00	0.00
146	0	0	0	.000	0.00	0.00
147	190	157	60	.209	3.17	3.90
149	3	2	1	.003	0.05	1.17
150	0	0	0	.000	0.00	0.00
151	781	644	245	.858	13.02	9.36
152	198	163	62	.217	3.30	5.76
153	35	28	11	.038	0.58	4.21
154	34	28	11	.037	0.57	0.60
155	10	9	3	.011	0.17	0.60
156	63	52	20	.069	1.05	1.92
157	392	322	123	.430	6.53	5.74
158	51	42	16	.056	0.85	1.70
159	0	0	0	.000	0.00	0.00
160	0	0	0	.000	0.00	0.00
161	0	0	0	.000	0.00	0.00
162	853	703	268	.937	14.22	9.88
163	0	0	0	.000	0.00	0.00
165	186	153	58	.204	3.10	3.48
167	604	498	190	.663	10.07	7.73
168	377	310	118	.414	6.28	6.53
169	390	321	122	.428	6.50	7.19
172	83	68	26	.091	1.38	1.02
173	8	6	2	.009	0.13	0.37
174	18	15	6	.020	0.30	0.75
176	75	62	24	.082	1.25	1.95
177	49	41	16	.054	0.82	0.84
179	51	42	16	.056	0.85	1.41
180	486	400	152	.534	8.10	5.49
181	710	584	223	.780	11.83	16.34
183	58	48	18	.064	0.97	1.23
184	185	152	58	.203	3.08	3.86
186	526	434	165	.578	8.77	5.77
189	11	9	3	.012	0.18	0.09
190	16	14	5	.018	0.27	0.16
194	4905	4039	1539	5.386	81.75	34.19
196	1490	1227	467	1.636	24.83	20.25
197	9	7	3	.010	0.15	0.08
199	21	17	7	.023	0.35	0.17
201	0	0	0	.000	0.00	0.00
204	8	6	2	.009	0.13	3.44
205	65	53	20	.071	1.08	2.81
208	960	791	301	1.054	16.00	15.85
210	27	22	8	.030	0.45	0.30
211	291	240	91	.320	4.85	3.39
212	32	26	10	.035	0.53	1.42
213	33	27	10	.036	0.55	0.37
216	1710	1408	536	1.878	28.50	26.99
219	49	41	16	.054	0.82	2.66
221	0	0	0	.000	0.00	0.00
222	0	0	0	.000	0.00	0.00
226	8	6	2	.009	0.13	0.12
227	33	27	10	.036	0.55	1.34
230	54	44	17	.059	0.90	1.22
232	52	43	16	.057	0.87	1.90
233	294	242	92	.323	4.90	4.17
234	517	426	162	.568	8.62	5.23
235	114	94	36	.125	1.90	4.04
236	9	7	3	.010	0.15	0.18
237	40	33	13	.044	0.67	0.56
238	10	9	3	.011	0.17	1.81
239	20	16	6	.022	0.33	0.52
240	29	23	9	.032	0.48	0.60
241	61	51	19	.067	1.02	1.30
242	23	19	7	.025	0.38	0.56
243	12	10	4	.013	0.20	0.88
252	2	1	0	.002	0.03	0.25
255	43	36	14	.047	0.72	0.50
256	25	21	8	.027	0.42	0.81
257	293	241	92	.322	4.88	5.72
258	1482	1220	465	1.627	24.70	12.72
259	1691	1392	530	1.857	28.18	16.45
260	0	0	0	.000	0.00	0.00
261	64	53	20	.070	1.07	0.72
265	614	505	192	.674	10.23	6.56
266	9	7	3	.010	0.15	0.10
292	2	1	0	.002	0.03	0.02
295	10	9	3	.011	0.17	0.07
309	211	174	66	.232	3.52	1.41
Total	51325	42270	16048	56.356	855.48	699.26

TABLE VII-34

EFFECTIVENESS OF BAT OPTIONS FOR DIRECT DISCHARGERS
POUNDS REMOVED FROM BPT TO LEVEL 2

Refinery No.	BOD	TSS	Oil & Grease	Chromium (Hex.)	Chromium (Total)	Phenol
1	120	99	38	.132	2.00	1.36
2	37	31	12	.041	0.62	0.34
3	16	14	5	.018	0.27	0.15
6	69	57	22	.076	1.15	0.84
7	74	61	23	.081	1.23	0.66
9	8	6	2	.009	0.13	0.10
10	56	46	17	.061	0.93	0.61
11	338	278	106	.371	5.63	3.57
12	45	37	14	.049	0.75	0.52
19	29	23	9	.032	0.48	0.26
20	570	469	179	.626	9.50	6.12
24	124	103	39	.136	2.07	1.08
30	54	44	17	.059	0.90	0.41
32	738	608	231	.810	12.30	7.36
37	961	792	302	1.005	16.02	10.56
40	1433	1180	449	1.573	23.88	14.40
41	2600	2141	816	2.855	43.33	26.41
43	566	466	177	.621	9.43	5.59
46	717	590	225	.787	11.95	7.01
49	70	58	22	.077	1.17	1.17
50	26	21	8	.029	0.43	0.63
51	1025	844	321	1.125	17.08	9.78
52	11	9	3	.012	0.18	0.37
53	81	67	25	.089	1.35	0.86
54	11	9	3	.012	0.18	0.13
56	69	57	22	.076	1.15	1.19
57	324	267	102	.356	5.40	4.35
59	205	169	64	.225	3.42	2.42
60	804	662	252	.883	13.40	7.98
61	987	813	310	1.084	16.45	10.00
62	4050	3335	1271	4.447	67.50	35.32
63	263	216	82	.289	4.38	3.79
64	420	346	132	.461	7.00	4.39
65	724	597	227	.795	12.07	7.13
67	3190	2627	1001	3.503	53.17	29.42
68	262	216	82	.288	4.37	4.68
70	25	21	8	.027	0.42	0.23
71	32	26	10	.035	0.53	0.57
72	58	48	18	.064	0.97	0.57
74	91	75	29	.100	1.52	1.17
76	454	374	143	.499	7.57	4.24
77	30	25	9	.033	0.50	0.57
80	165	136	52	.181	2.75	2.24
81	192	158	60	.211	3.20	2.08
83	514	424	161	.564	8.57	5.93
84	147	121	46	.161	2.45	2.12
85	605	498	190	.664	10.08	6.81
87	12	10	4	.013	0.20	0.09
88	92	75	29	.101	1.53	0.79
89	19	16	6	.021	0.32	0.18
90	15	12	5	.016	0.25	0.25
91	9	7	3	.010	0.15	0.07
92	3750	3088	1176	4.118	62.50	32.40
93	14	11	4	.015	0.23	0.11
94	225	185	71	.247	3.75	2.73
96	4080	3360	1280	4.480	68.00	37.95
97	75	62	24	.082	1.25	1.19
98	778	641	244	.854	12.97	8.17
99	47	38	15	.052	0.78	0.72
100	21	17	7	.023	0.35	0.19
102	197	162	62	.216	3.28	2.01
103	71	58	22	.078	1.18	0.63
104	1470	1211	461	1.614	24.50	15.90
105	138	114	43	.151	2.30	2.32
106	600	494	188	.659	10.00	7.51
108	156	128	49	.171	2.60	1.61
109	10	9	3	.011	0.17	0.58
112	28	23	9	.031	0.47	0.22
113	133	110	42	.146	2.22	1.38
115	1224	1008	384	1.344	20.40	10.03
116	449	369	141	.493	7.48	4.40
117	122	100	38	.134	2.03	1.19
118	85	70	27	.093	1.42	0.71
119	143	117	45	.157	2.38	1.17
120	57	47	18	.063	0.95	0.50
121	1104	909	346	1.212	18.40	10.58
122	790	651	248	.867	13.17	6.78
124	206	169	64	.226	3.43	2.00
125	216	178	68	.237	3.60	2.08

TABLE VII-34 - Continued

Refinery No.	BOD	TSS	Oil & Grease	Chromium (Hex.)	Chromium (Total)	Phenol
126	153	126	48	.168	2.55	2.10
127	24	20	8	.026	0.40	0.35
129	5	4	1	.005	0.08	0.10
131	881	725	276	.967	14.68	8.46
132	1430	1177	448	1.570	23.83	15.96
133	873	719	274	.959	14.55	8.02
134	253	209	80	.278	4.22	4.11
144	66	54	21	.072	1.10	1.23
146	5	4	1	.005	0.08	0.08
147	358	295	112	.393	5.97	4.11
149	75	62	24	.082	1.25	1.26
150	79	65	25	.087	1.32	1.39
151	1043	859	327	1.145	17.38	9.69
152	479	394	150	.526	7.98	6.11
153	288	237	90	.316	4.80	4.53
154	58	48	18	.064	0.97	0.64
155	43	36	14	.047	0.72	0.64
156	158	130	49	.173	2.63	2.04
157	590	485	185	.648	9.83	6.00
158	137	112	43	.150	2.28	1.80
159	27	22	8	.030	0.45	0.47
160	20	16	6	.022	0.33	0.48
161	3	2	1	.003	0.05	0.94
162	1119	922	351	1.229	18.65	10.22
163	99	82	31	.109	1.65	1.68
165	328	271	103	.360	5.47	3.66
167	841	693	264	.923	14.02	8.03
168	632	520	198	.694	10.53	6.85
169	682	562	214	.749	11.37	7.56
172	112	93	35	.123	1.87	1.05
173	28	23	9	.031	0.47	0.39
174	58	48	18	.064	0.97	0.80
176	167	137	52	.183	2.78	2.06
177	82	68	26	.090	1.37	0.88
179	119	98	37	.131	1.98	1.50
180	628	518	197	.690	10.47	5.67
181	1450	1195	455	1.592	24.17	17.28
183	112	93	35	.123	1.87	1.30
184	351	289	110	.385	5.85	4.07
186	669	551	210	.735	11.15	5.96
189	12	10	4	.013	0.20	0.09
190	19	16	6	.021	0.32	0.16
194	3370	2776	1057	3.700	56.17	32.24
196	2140	1763	672	2.350	35.67	21.07
197	10	9	3	.011	0.17	0.08
199	23	19	7	.025	0.38	0.17
201	88	73	28	.097	1.47	1.63
204	223	184	70	.245	3.72	3.72
205	216	178	68	.237	3.60	3.00
208	1560	1285	489	1.713	26.00	16.61
210	35	28	11	.038	0.58	0.31
211	382	315	120	.419	6.37	3.50
212	109	90	34	.120	1.82	1.52
213	42	35	13	.046	0.70	0.38
216	2690	2215	844	2.954	44.83	28.03
219	198	163	62	.217	3.30	2.85
221	69	57	22	.076	1.15	2.62
222	5	4	1	.005	0.08	0.16
226	12	10	4	.013	0.20	0.13
227	104	85	32	.114	1.73	1.43
230	109	90	34	.120	1.82	1.29
232	151	125	48	.166	2.52	2.03
233	435	358	136	.478	7.25	4.35
234	630	519	198	.692	10.50	5.37
235	323	266	101	.355	5.38	4.30
236	17	14	5	.019	0.28	0.19
237	59	48	18	.065	0.98	0.59
238	120	99	38	.132	2.00	1.94
239	44	36	14	.048	0.73	0.55
240	54	44	17	.059	0.90	0.63
241	118	98	37	.130	1.97	1.38
242	49	41	16	.054	0.82	0.60
243	63	52	20	.069	1.05	0.95
252	17	14	5	.019	0.28	0.26
255	56	46	17	.061	0.93	0.51
256	66	54	21	.072	1.10	0.87
257	532	439	167	.584	8.87	6.02
258	1663	1370	522	1.826	27.72	12.95
259	2020	1664	634	2.218	33.67	16.87
260	1	1	0	.001	0.02	0.31
261	83	68	26	.091	1.38	0.75
265	770	634	241	.845	12.83	6.75
266	11	9	3	.012	0.18	0.10
292	2	1	0	.002	0.03	0.02
295	10	9	3	.011	0.17	0.07
309	211	174	66	.232	3.52	1.41
Total	73172	60265	22950	80.289	1219.54	744.16

SECTION VIII

BAT

The factors considered in assessing best available technology economically achievable (BAT) include the age of equipment and facilities involved, the process employed, process changes, non-water quality environmental impacts (including energy requirements), and the costs of application of such technology (Section 304(b)(2)(B)). In general, the BAT technology level represents, at a minimum, the best economically achievable performance of plants of various ages, sizes, processes or other shared characteristics. Where existing performance is uniformly inadequate, BAT may be transferred from a different subcategory or category. BAT may include process changes or internal controls, even when not common industry practice.

The statutory assessment of BAT "considers" costs, but does not require a balancing of costs against effluent reduction benefits. In developing the proposed BAT, however, EPA has given substantial weight to the reasonableness of costs. The Agency has considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels.

Despite this expanded consideration of costs, the primary determinent of BAT remains effluent reduction capability. Effluent limitations for the petroleum refining industry are expressed as mass limitations, i.e., restrictions on the total quantity of pollutants which may be discharged. Since the total mass of pollutants in an effluent stream depends on both the total effluent flow and the concentration of pollutants in that flow, the six options considered for BAT include various combinations of flow reduction and improved performance of waste treatment technology.

BAT OPTIONS CONSIDERED

OPTION ONE - Require effluent limitations based on an average flow reduction from model flow of 27 percent achieved through greater reuse and recycle of wastewater. This option would not require additional end-of-pipe treatment since limitations would be based upon the performance of BPT end-of-pipe technology; phenol (4AAP) limitations, however, would be based on a long term achievable concentration of 19 ug/l. (See Section III).

This level of flow is now achieved by 50 percent of the facilities in the industry. $19.3 million additional investment would be required

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with an annual cost of $7.7 million including interest and depreciation.

OPTION TWO - Require effluent limitations based on an average 52 percent flow reduction achieved through greater reuse and recycle of wastewater. This option would not require additional end-of-pipe treatment since limitations would be based on the performance of BPT end-of-pipe technology. Mass limitations on 4AAP phenol would be based on the 19 ug/l currently achieved by industry.

This option was based on an average of the flows of all refineries which are achieving flows lower than those predicted by the proposed flow model. This produces limitations based on flows now achieved by 38 percent of the industry; an average reduction of 52 percent would be required throughout the industry.

Although precise costs have not yet been calculated for this option, EPA has concluded, based on its technological evaluation of the industry, that the costs for Option Two approximate those projected for Option three below. $113.0 million additional investment would be required with an annual cost of $48.7 million including interest and depreciation. This amounts to $0.0002 per gallon of product.

In order to confirm its assessment of costs EPA intends to conduct an engineering field survey of the costs associated with Option Two. This survey will be completed and a report prepared prior to final promulgation of these regulations. EPA will publish a notice in the Federal Register when the report is available to the public.

OPTION THREE - Require effluent limitations based on a combination of OPTION ONE flow reduction and improved end-of-pipe treatment. Improved end-of-pipe treatment was evaluated with the use of powdered activated carbon (PAC). This combination of treatment produces mass limitations equivalent to those produced by flow reduction alone under Option Two.

$113.0 million additional investment would be required with an annual cost of $48.7 million including interest and depreciation. This amounts to $0.0002 per gallon of product.

OPTION FOUR - Require mass limitations based on Option Two plus segregation and separate treatment of cooling tower blowdown. Cooling tower blowdown would be treated for metals (reduction of hexavalent chromium to trivalent chromium, pH adjustment, precipitation and clarification). Limitations for other process streams would be based on treatment in existing BPT treatment systems.

Treatment of segregated streams may remove more toxics than would biological treatment of a combined, more dilute, waste stream.

Potential contamination of biological sludges by cooling tower biocides (generally containing chromium and zinc) would be reduced. Removal of organic toxic pollutants in the biological treatment system may be increased since the wastewater would not be diluted with cooling tower water prior to treatment.

EPA has not made a detailed cost analysis for this option. While the cost of metals treatment can be estimated, the cost of segregating cooling tower blowdown from other process streams cannot be estimated with available data. The engineering survey, described above (See Option 2) also will collect data on the technical requirements and cost of cooling water segregation.

OPTION FIVE - Require effluent limitations based on Option One flow reductions plus the addition of granular activated carbon (GAC) to control residual toxic organic pollutants dissolved in the wastewater discharged from Option 1 technology.

Although results of the Agency study were inconclusive (see Section V), it can be generally stated that toxic pollutant removal increases with the use of GAC. This removal, however, appears to be only marginally better than with PAC (Option Two) and the cost of GAC is much greater than PAC.

EPA estimates that this option would require direct discharging refineries to incur an annualized cost of $363 million.

OPTION SIX - Prohibit discharge from existing refineries. This could be achieved by further reuse and recycle, evaporation, or reinjection of wastewaters. Fifty-five existing refineries already have eliminated discharge.

This is a demonstrated technology, but costs were not calculated for this option. While additional costs for building a new refinery to eliminate discharge can be calculated (150), the costs of retrofitting an existing refinery are highly site specific. Costs, however, would be significantly higher than costs for applying any of the other options.

BAT SELECTION AND DECISION CRITERIA - EPA has selected Option Two as the basis for proposed effluent limitations. This option was selected because it was best supported by available data and because it reduces total pollutant discharges through the use of proven technology. Since this level represents the average of the best in the industry EPA believes that it demonstrates reasonable further progress towards the Clean Water Act's goal of the elimination of the discharge of pollutants. Further, these limitations are also technologically and economically achievable through the use of Option Three. Thus, all facilities have several ways to achieve this limitation. They may meet it totally through flow reduction or through a combination of flow reduction and improved treatment.

Available data show that existing treatment already reduces the concentration of 4AAP phenols to 19 ug/l (See Section III). Consequently mass limitations on phenols will be based on that achievable concentration. In order to validate this decision, EPA is presently requesting, under section 308 of the Act, that approximately 37 refineries believed to have installed BPT model technology send data to EPA for further evaluation of what constitutes a proper achievable concentration of 4AAP phenols based on BPT treatment technology. That data also will allow EPA to determine whether the variability factors used to establish daily and monthly fluctuations should be changed as a result of the lower concentrations. Mass limitations on all other pollutants are based on those final concentrations already part of the BPT limitations (3):

Option Four still remains a serious candidate for the basis of final regulations. EPA has data establishing that greater quantities of metals and toxic organics can be removed when introduced into separate treatment systems at higher concentrations. EPA has only limited data on the costs required to segregate flows from cooling towers. This matter is presently under study.

Option Five was not selected because GAC allows only slightly better pollutant removal than PAC (Option Three) and because the cost of GAC is considerably higher than the cost of PAC.

Option Six was not selected because, in the Agency's judgement, the costs of retrofitting to eliminate discharge on a uniform national basis would be significantly higher than the selected option and would result in a substantial number of plant closures. Nevertheless, this option still remains a serious candidate for any subsequent revisions of BAT limitations, especially for certain sizes and/or types of plants.

The following derivation presents the development of mass limitations for phenol, based upon Option 2, from the flow model discussed in Section IV.

1) Mass = Flow x concentration x variability (equation 1)
BAT Mass = .48 x Mass (based on average 1976 industry flow)

2) Flow (see Section IV) $= 0.004C + 0.046K + 0.048(A+L)$ (equation 2)
where Flow = million gallons per day
C = summation of the crude oil and fed natural gas liquids to the atmospheric distillation, vacuum distillation, and crude desalting (in units of 1,000 bbls/day)

K = summation of the petroleum liquids fed to the catalytic cracking processes (in unit of 1,000 bbls/day)
A = summation of the petroleum liquids fed to the asphalt processes (in units of 1,000 bbls/day)
L = summation of the petroleum liquids fed to the lube processes (in units of 1,000 bbls/day)

3) Concentration and variability factor
phenol = 19 ug/l (concentration)
1.7 (variability factor for 30 day averages)

4) Sample Calculation
Mass = Flow x concentration x variability factor x .48

$$= .004C + .046\underline{K} + .048(\underline{A}+\underline{L}) \times .019 \text{ mg/l} \times 1.7 \times 8.34 \times .48$$

$$\underline{\text{Mass}}\ \underline{\text{(lbs of phenol)}} = (0.0005C) + (0.0060K) + (0.0062(A+L)$$

The following example presents the derivation of a phenol effluent limitation for typical refinery.

Refinery X Y Z

Refinery Processes	Refinery Capacity 1000 bb/day
Atmospheric Crude Distillation	100
Vacuum Crude Distillation	75
Desalting	50
total crude processes (C)	225
FCC	25
Hydrocracking	20
Total cracking processes (K)	45
Asphalt Production	5
Hydrofining	3
Wax processing	1
Total asphalt and lube processes (AL)	9

Using the equation given in item 4 above:

Average of daily values for 30 consecutive days of phenol discharge, (lbs/day) = $.0005\ (225) + .0060\ (45) + 6.2 \times 10^{-3}\ (9) = .44$

SECTION IX

BCT

The 1977 amendments added Section 301(b)(4)(E) to the Act, establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those defined in Section 304(b)(4) - BOD, TSS, fecal coliform, and pH - and any additional pollutants defined by the Administrator as "conventional." On July 30, 1978, EPA designated oil and grease as a conventional pollutant (44 Fed. Reg. 44501).

BCT is not an additional limitation; rather it replaces BAT for the control of conventional pollutants. BCT requires that limitations for conventional pollutants be assessed in light of a new "cost-reasonableness" test which involves a comparison of the cost and level of reduction of conventional pollutants from the discharge of publicly owned treatment works (POTW) to the cost and level of reduction of such pollutants from a class or category of industrial sources. As a part of its review of BAT for certain "secondary" industries, the Agency has promulgated a methodology for this cost test. (See 44 FR 50732, August 29, 1979). The Agency compares industry costs with that of an "average" POTW with a flow of 2 mgd and costs (1977 dollars) of $1.18 per pound of pollutant removal (BOD and TSS).

EPA applied this methodology to the costs for removing conventional pollutants in the petroleum refining industry and concluded that BCT limitations based on a 52 percent reduction in total effluent flow by greater recycle and reuse of wastewaters (BAT Option Two, See section IX) or a 52 percent reduction in pollutants discharged by a combination of flow reduction and powdered activated carbon enhancement of activated sludges (BAT Option three) are reasonable. This is based upon a cost of depreciation and interest of 25 percent of capital costs. At this level, the total annualized cost for BCT technology is $48.7 million and EPA projects that 123.3 million pounds of BOD and TSS will be removed throughout the industry by Option Two technology (See Tables VII-30 and VIII-32). Based on these figures, the cost to pollutant reduction ratio for Option Two is $1.00 per pound of BOD and TSS removed (compared to a POTW cost of $1.18 per pound of BOD and TSS). Therefore, EPA proposes BCT effluent limitations at the proposed BAT (OPTION TWO) level.

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SECTION X

NSPS

The basis for new source performance standards (NSPS) under Section 306 of the Act is the best available demonstrated technology. New plants have the opportunity to design the best and most efficient petroleum refining processes and wastewater treatment technologies; Congress therefore directed EPA to consider the best demonstrated process changes, in-plant controls, and end-of-pipe treatment technologies capable of reducing pollution to the maximum extent feasible.

NSPS OPTIONS CONSIDERED

OPTION ONE - Require performance standards based on the same technology proposed for BAT (see Section IX), including wastewater flow control by recycle and reuse of wastewaters after BPT treatment. As discussed under BAT Option Two, application of this technology will ensure a high degree of removal of toxic pollutants. Similar reductions in pollutant mass discharge can be achieved by BAT Option Three.

OPTION TWO - Require performance standards based on granular activated carbon (BAT Option Five). As discussed under BAT Option Five, GAC allows somewhat better pollutant removals than NSPS Option One, but is considerably more expensive.

OPTION THREE - Require a performance standard to eliminate discharge. Unlike BAT Option Six, there is no cost of retrofitting to comply with such a requirement. No discharge of refinery wastes is a demonstrated technology; EPA has identified fifty-five refineries which do not discharge. The American Petroleum Institute (API) has published a technical report (150) which evaluates the technologies capable of eliminating discharge of refinery wastes. The water reuse schemes and end-of-pipe technologies described in the API Report are being used in the refining industry, used by other industries, or successfully tested on a pilot scale. The report also calculates the costs to be expected if those technologies were designed into a new refinery (i.e. without the need to retrofit existing equipment). This option would require a new source of the size and configuration likely to be built in the 1980's to incur additional investment over BPT of $9.5 million with an annual cost of $3.5 million including interest and depreciation (1977 dollars).

NSPS SELECTION AND DECISION CRITERIA - EPA has selected Option Three as the basis for proposed new source performance standards. No discharge is a demonstrated technology in the petroleum refining industry and, based on available data, can be economically achieved. Consequently, EPA believes that the Act requires that Option Three be the basis for NSPS.

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SECTION XI

PRETREATMENT STANDARDS

Section 307(b) of the Act requires EPA to promulgate pretreatment standards for both existing sources (PSES) and new sources (PSNS) of pollution which discharge their wastes into publicly owned treatment works (POTWs). These pretreatment standards are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTW's. In addition, the Clean Water Act of 1977 adds a new dimension to these standards by requiring pretreatment of pollutants, such as heavy metals, that limit POTW sludge management alternatives. The legislative history of the Act indicates that pretreatment standards are to be technology based and, with respect to toxic pollutants, analagous to BAT. The Agency has promulgated general pretreatment regulations which establish a framework for the implementation of these statutory requirements. (See 43 Fed. Reg. 27736 June 26, 1978).

A determination of which pollutants may pass through or be incompatible with POTW operations, and thus be subject to pretreatment standards, depends on the level of treatment employed by the POTW. In general, more pollutants pass through or interfere with a POTW employing primary treatment (usually physical separation by settling) than one which has installed secondary treatment (settling plus biological stabilization) (See Section IV).

Section 301(b)(1)(B) of the Act requires most POTW's to have installed secondary treatment by July 1, 1977. There are, however, two groups of POTW's which have not yet met this requirement. One group remains subject to the obligation and contains POTW's which are scheduled to install secondary treatment within the next few years. A second group of POTWs will be exempt from the requirement to install secondary treatment. Under Section 301(h) of the Act, POTWs which discharge into marine waters may, under certain circumstances, receive a waiver from this requirement. EPA has proposed regulations dealing with the issuance of section 301(h) waivers. 43 Fed. Reg. 301 Vol. 44 No. 117, Friday, June 15, 1979.

OPTION ONE - Establish pretreatment for all refineries based on metals removal (pH adjustment, precipitation, and clarification) and existing PSES controls. Metals removal would be required only for cooling tower blowdown, since that is the major source of the heavy metals of concern -- chromium and zinc. (Under this option, organic priority pollutants would pass through primary POTWs which have not yet complied with Section 301(b)(1)(B) of the Act and those POTWs which are granted waivers under Section 301(h)).

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The regulation would require the 53 affected indirect discharging refineries to incur $9.6 million additional investment with annual costs of $5.2 million including interest and depreciation. A new indirect discharging refinery of the size and configuration likely to be built in the 1980's would incur additional investment of $0.3 million with annual costs of $0.2 million including interest and depreciation.

OPTION TWO - Establish two pretreatment standards. Pretreatment for those refineries discharging into POTWs which have been granted waivers under Section 301(h) would be based on concentrations achievable after application of BPT technology. Pretreatment for other indirect discharging refineries would be the same as Option 1.

The cost of this option cannot be specifically calculated since there are no POTWs which have been granted waivers under section 301(h). Costs were developed, however, for each indirect discharging refinery to install biological treatment (See Section VI).

SELECTION OF PRETREATMENT TECHNOLOGY AND DECISION CRITERIA - EPA has selected Option Two as the basis for pretreatment standards. Based on its sampling and analysis program, EPA has determined that pollutants found in petroleum refining wastes after present PSES treatment do not pass through secondary POTWs and that only metals limit the POTW sludge management alternatives (See Section III). Consequently, for metals only, EPA is proposing additional pretreatment standards for indirect dischargers whose wastes go to POTWs employing secondary treatment.

The Agency additionally proposes that this limitation apply to those indirect dischargers whose wastes go to a primary POTW which is scheduled to install secondary treatment. Although EPA has determined that petroleum refining wastes pass through primary POTWs, the Agency believes that it would be improper to require industrial sources discharging into such POTWs to install treatment systems which will be unnecessary when the POTWs come into compliance with the requirement of secondary treatment.

EPA is, however, proposing specific pretreatment standards based on application of BAT technology for those indirect dischargers whose wastes go to POTWs which have been granted 301(h) waivers. Since POTWs with 301(h) waivers will remain at primary treatment, only specific limitations on indirect dischargers will ensure that their wastes do not pass through into waters of the United States. Such standards, however, will apply only where a valid 301(h) waiver has been granted. Those sources discharging into a POTW which has a pending application for a 301(h) waiver will be subject to the generally less stringent pretreatment standards based on secondary treatment in the POTW until such time as the waiver is finally approved.

SECTION XII

ACKNOWLEDGEMENTS

This document is based largely on a contractor's report, the purpose of which was to present the technical data base developed to meet EPA's requirements for further development and review of BAT effluent limitations for new source performance standards and pretreatment standards for the petroleum refining point source category. Burns and Roe of Paramus, New Jersey, under contract to EPA, submitted their report in December of 1977 (125).

The following members of the Burns and Roe technical staff made significant contributions to the overall project effort and the development of this report:

Arnold S. Vernick, P.E.	Project Manager
Paul D. Lanik, P.E.	Project Engineer
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Roy Ehlenberg	Systems Designer
Tom H. Fieldsend	Environmental Engineer
Gary C. Martin	Civil Engineer
Gerald Smit, P.E.	Operations Research Specialist

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Chevron, U.S.A., Inc., Perth Amboy, NJ
EXXON Company, U.S.A., Linden, NJ
Getty Refining and Marketing Co., Delaware City, DE
Mobil Oil Corporation, Paulsboro, NJ
Sun Oil Co., Marcus Hook, PA
Texaco, Inc., Westville, NJ

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Atlantic Richfield Co., Philadelphia, PA
Clark Oil and Refining Corporation, Hartford, IL
Coastal States Petrochemical Co., Corpus Christi, TX
Continental Oil Company, Ponca City, OK
EXXON Company, U.S.A., Baytown, TX
EXXON Company, U.S.A., Benicia, CA
EXXON Company, U.S.A., Billings, MT
Getty Refining and Marketing Company, El Dorado, KS
Gulf Oil Company, Philadelphia, PA
Hunt Oil Company, Tuscaloosa, AL
Mobil Oil Corporation, Augusta, KS
Phillips Petroleum Company, Sweeny, TX
Quaker State Oil Refining Corporation, Congo, WV
Shell Oil Company, Anacortes, WA
Sun Oil Company, Toledo, OH
Texaco, Inc., Lockport, IL

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SECTION XIII

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SECTION XIV

GLOSSARY AND ABBREVIATIONS

Glossary

Act: The October 18, 1972 Amendments to the Federal Water Pollution Control Act, P.L. 92-500.

Administrator: Administrator of the U.S. Environmental Protection Agency, whose duties are to administer the Act.

Appendix A Pollutants: Those pollutants listed in Appendix A of the Settlement Agreement of June 7, 1976 (see Table III-1).

Best Available Technology Economically Achievable (BATEA or BAT): Treatment required by July 1, 1983 for industrial discharge to surface waters as defined by Section 301 (b) (2) (A) of the Act.

Best Practicable Control Technology Currently Achievable (BPCTCA or BPT): Treatment required by July 1, 1977 for industrial discharge to surface waters as defined by Section 301 (b) (1) (A) of the Act.

Best Available Demonstrated Technology (BADT): Treatment required for new sources as defined by Section 306 of the Act.

Catalyst: A substance which can change the rate of a chemical reaction, but which is not itself involved in the reaction.

Cluster Analysis: A statistical procedure which solves the problem of separating objects into groups so that each object is more like objects in the same group than like objects in other groups.

Cross-check Editing: The determination of a value's validity based on the occurrence of a value of some other variable.

Data Validation: An operation performed to insure the accuracy and reliability of raw input information.

Dependent Variable: A variable whose value is a function of one or more independent variables.

Deterministic Variable: A variable whose values are purely determined to be a function of physical facts.

Discriminant Analysis: A statistical procedure to assign an entity whose population identity is not known to a population of known characteristics.

Dummy Variable: A symbol representing the statistical encoding of a qualitative value.

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Economics Survey: Survey to be mailed by the Office of Analysis and Evaluation of EPA to the petroleum refining industry, pursuant to Section 308 of the Act. Data on the economic status of petroleum refineries will be requested.

End-of-Pipe Treatment (control): Those treatment technologies that are used after gravity oil separation.

Flow Model: A mathematical model of the effluent wastewater flow, developed through the use of multiple linear regression techniques.

Forward Stepping Multiple Linear Regression: A multiple linear regression procedure in which the order that the independent variables enter into the regression model is determined by the respective contribution of each variable to explain the variability of the dependent variables.

Independent Variable: A variable whose value is not dependent on the value of any other variable.

In-plant Control: Those treatment techniques that are used to reduce, reuse, recycle, or treat wastewater prior to end-ofpipe treatment.

Linear Regression: A method to fit a line through a set of points such that the sum of squared vertical deviations of the point values from the fitted line is a minimum, i.e. no other line, no matter how it is computed, will have a smaller sum of squared distances between the actual and predicted values of the dependent variable.

Listwise Deletion of Missing Data: A procedure to handle the absence of some of the information in a regression analysis by eliminating any data point with absent information from all calculations.

Magnitude of Entry Editing: The determination of a value's validity based solely on size of the figure, and is a test typically performed on raw input data.

Mathematical Model: A quantitative equation or system of equations formulated in such a way as to reasonably depict the structure of a situation and the relationships among the relevant variables.

Mean Value: The statistical expected or average figure.

Multicollinearity: A regression analysis situation in which some or all of the independent variables are very highly intercorrelated. The presence of this situation may cause model development to be extremely difficult or impossible.

Multiple Linear Regression: A method to fit a plane through a set of points such that the sum of squared distances between the individual observations and the estimated plane is a minimum. This statistical technique is an extension of linear regression in that more than one independent variable is used in the least squares equation.

Normalized Coefficients: Regression constants whose magnitudes are referenced to some value.

Pairwise Deletion of Missing Data: A procedure to handle the absence of some of the information in a regression analysis by eliminating the data point from only those calculations which use the absent figures.

Portfolios A, B: The two sections of the 1977 U.S. EPA Petroleum Refining Industry Survey (see "The Survey").

Priority Pollutants: Those pollutants included in Table III-3.

Probabilistic Variable: A symbol whose values vary with some likelihood of occurrence distribution. The values cannot be determined "a priori".

Process Configuration: A numerical measurement of a refinery's process complexity; developed for use in calculating BPT guidelines for this industry.

Process Factor: A factor based upon process configuration, used in calculating a petroleum refinery's BPT limitations.

Random Process: A procedure which varies according to some probability function.

Random Variable : A variable whose values occur according to the distribution of some probability function.

Regression Statistics: Values generated during a regression analysis which identify the significance, or reliability, of the regression generated figures.

Regression Model: A mathematical model, usually a single equation, developed through the use of a least squares linear regression analysis.

Residuals: The differences between the expected and actual values in a regression analysis.

Settlement Agreement of June 7, 1976: Agreement between the U.S. Environmental Protection Agency (EPA) and various environmental groups, as instituted by the United States District Court for the District of Columbia, directing the EPA to study and promulgate regulations for a list of chemical substances, referred to as Appendix A Pollutants.

Significance: A statistical measure of the validity, confidence, and reliability of a figure.

Size Factor: A factor, based upon a petroleum refinery's size, used in calculating a petroleum refinery's BPT limitations.

Sour Waters: Those wastewaters containing sulfur compounds, such as sulfides and mercaptans.

Statistical Stability: A condition whereby if a process were to be repeated over time, differences would occur due solely to random processes.

Statistical Variance: The sum of the squared deviations about the mean value in proportion to the likelihood of occurrence. A measure used to identify the dispersion of a set of data.

The 1977 EPA Petroleum Refining Industry Survey (The Survey): A survey mailed pursuant to Section 308 of the Act to 274 refineries on February 11, 1977, and an additional 23 refineries on August 12, 1977. The survey was issued in two sections, referred to as Portfolio A and Portfolio B, and requested data on various aspects of process operations, wastewater production, and wastewater treatment.

Tolerance Limits: Numerical values identifying the acceptable range of some variable.

Traditional Pollutant Parameters: Pollutant parameters considered, and used, in the development of BPT guidelines. These parameters include, but are not limited to BOD, COD, TOC, TSS, and ammonia.

Abbreviations

API:	American Petroleum Institute
BATEA (BAT):	Best Available Technology Economically Achievable
bbl(Bbl):	Barrel
BPCTCA (BPT):	Best Practicable Control Technology Currently Available
B & R:	Burns and Roe
DMR:	Discharge Monitoring Report
EPA:	U.S. Environmental Protection Agency
gal:	Gallon
MGD:	Million gallons per day
mg/L:	Milligrams per liter
POTW:	Publicly Owned Treatment Works
RETA:	Ryckman, Edgerley, Tomlinson and Associates
RSKERL:	Robert S. Kerr Environmental Research Laboratory
S & A:	Surveillance and Analysis
SPSS:	Statistical Package for the Social Sciences
ug/l:	Micrograms per liter

APPENDIX 1

Petroleum Refinery Industry

Survey Form and Supplemental Flow Question

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CODE NO.__________

PETROLEUM REFINING INDUSTRY SURVEY

FOR REVISION OF "BEST AVAILABLE TECHNOLOGY" (BAT) EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS

PORTFOLIO A

NOTES

(1) Portfolio A is to be mailed within 30 days of receipt and Portfolio B within 60 days of receipt to:

Robert B. Schaffer, Director
Effluent Guidelines Division
U.S. Environmental Protection Agency (WH-552)
Washington, D.C. 20460

(2) All flow rates requested in this survey are annual average values (for calendar year 1976) and in units of million gallons per day (MGD), unless otherwise specified.

I GENERAL INFORMATION

A. Name of Refinery______________________________

B. Street Address______________________________

____

____

C. Refinery Contact______________________________

D. Telephone Number______________________________

II REFINERY PROCESS DATA

Definitions for Following Table:

1. "First Generation Petrochemicals" are compounds such as BTX, olefins, Cyclohexane, etc. which are produced through processes normally associated with refineries such as isomerization or distillation.

2. "Second Generation Petrochemicals" are compounds such as alcohols, ketones, cumenes, styrenes, etc. which are produced through more complex chemical reactions.

3. "Treating and Finishing Processes" should include only those processes that are used to upgrade the intermediate or final product streams, or other product streams that are blended to result in final products.

PORTFOLIO A (continued)

CODE NO._________

II REFINERY PROCESS DATA (Continued)

Please include a simple process block flow diagram of the refinery operations with the completed survey form.

Indicate which of the processes listed below are utilized at your refinery, and the respective process rates for the period 1/1/76 - 12/31/76.

Process	A. 1976 Stream Day Capacity Units: 1000 bbl/day	B. Calendar Day Rate 1976 Avg. Units: 1000 bbl/day	Year Process Installed
1. Atmospheric Crude Distillation			
2. Crude Desalting			
3. Vacuum Crude Distillation			
4. Visbreaking			
5. Thermal Cracking			
6. Fluid Catalytic Cracking			
7. Moving Bed Catalytic Cracking			
8. H_2SO_4 Alkylation			
9. HF Alkylation			
10. Hydrocracking			
11. Hydroprocessing			
12. Catalytic Reforming			
13. Catalytic Polymerization			
14. Aromatic Petrochemicals			
15. Delayed Coking			
16. Fluid Coking			
17. Isomerization			
18. Asphalt Production			
19. Ammonia Petrochemicals			
20. Alkylate Production			
Lube Oil Processes			
21. Hydrofining, Hydrofinishing, Lube Hydrofining			
22. White Oil Manufacture			

PORTFOLIO A (continued)

CODE NO. ________

Process	A. 1976 Stream Day Capacity Units: 1000 bbl/day	B. Calendar Day Rate 1976 Avg. Units: 1000 bbl/day	Year Process Installed
Lube Oil Processes			
23. Propane Dewaxing, Propane Deasphalting, Propane Fractioning, Propane Deresining			
24. Duo Sol, Solvent Treating, Solvent Extraction, Duotreating, Solvent Dewaxing, Solvent Deaspnalt			
25. Lube Vac Twr, Oil Fractionation, Batch Still (Naptha Strip), Bright Stock Treating			
26. Centrifuge & Chilling			
27. MEK Dewaxing, Ketone Dewaxing, MEK-Toluene Dewaxing			
28. Deoiling (wax)			
29. Naphthenic Lubes			
30. SO_2 Extraction			
31. Feed Preparation			
32. 200°F Softening Point Unfluxed Asphalt			
33. Compounding			
34. Wax Pressing			
35. Wax Plant (with Neutral Separation)			
36. Furfural Extracting			
37. Clay Contacting - Percolation			
38. Wax Sweating			
39. Acid Treat			
40. Phenol Extraction			
Treating & Finishing			
41. Bender Treating			
42. Petreco Locap Gasoline Sweetening			

PORTFOLIO A (continued)

CODE NO.__________

Process	A. 1976 Stream Day Capacity Units: 1000 bbl/day	B. Calendar Day Rate 1976 Avg. Units: 1000 bbl/day	Year Process Installed
Treating & Finishing			
43. Asphalt Oxidizer			
44. Caustic or KOH Treating, For example: Caustic or KOH Treating for (1), H_2S (2), Mercaptan (3), Cresylic Acid (4) Naphenic Acid (5), PWS MEA for COS Removal, etc.			
45. Water Wash			
46. Mercapfining, Pentane Mercapfining			
47. Merox Treating (i.e. Liquid-Liquid Extraction, Liquid-Liquid Sweetening, and Fixed Bed			
48. C_3 & C_4 Scrubbing, Girbitol Treating			
49. Linde			
50. Doctor Treating			
51. Sulfuric Acid Treating			
52. Unisol Treating			
53. SO_2 Treating			
54. Hydro Treating			
55. Perco (copper chloride), Copper Slurry			
56. Inhibitor Sweeting			
57. KCr			
58. Clay Treating, Bauxite Treating			
59. Hypochlorite Sweetening			
60. Salt Brightening or Drying			
61. Sulfinol			
62. Unclassified Treating and Finishing			

PORTFOLIO A (continued)

CODE NO. __________

Process	A. 1976 Stream Day Capacity Units: 1000 bbl/day	B. Calendar Day Rate 1976 Avg. Units: 1000 bbl/day	Year Process Installed
Petrochemicals			
63. Isobutane Production			
64. Carbon Black			
65. Heptene			
66. Sulfolane			
67. OxoAlcohol			
68. Napthalene			
69. Butadiene			
70. Aliphatics			
71. Cumene			
72. Paraxylene Charge			
73. Xylene Fractionation			
74. Polypropene, Polyisobutylene, Poly Feed Preparation, Trimer-Tetramer			
75. Phenol, Oxonation Additives Mfg., Polystyrene Resin, Lube Oil Depressant			
76. Detergents Alkylate			
77. Cresylic Acid			
78. Styrene			
79. Naphthenic Acid			
80. Alpha Olifins			
81. Nitric Acid			
82. Phthalic Anhydride			
83. Butyl Rubber			
84. Polyproplene			
85. Cyclohexane			
86. Solvent hydrotreater			
87. HMU			
88. Unclassified Petrochem			

PORTFOLIO A (continued)

CODE NO.__________

Process	A. 1976 Stream Day Capacity Units: 1000 bbl/day	B. Calendar Day Rate 1976 Avg. Units: 1000 bbl/day	Year Process Installed
Other Processes			
89. Asphalt, Asphalt Oxidizing, Asphalt Emulsifying			
90. Sulphur Recovery, Sulphur Production			
91. Hydrogen, Reformer Feed Prep, Steam Methane Reformer, Partial Oxidation			
92. Gas Plant			
93. DEA Treating			
94. CO_2 Recovery			
95. Furfural			
96. Dubbs Pitch			
97. Solvent Decarbonizing			
98. Hydrodemethylation			
99. Catalyst Manufacture			
100. Gasoline Additives			
101. Linear Paraffins			
102. Butadiene Concentration			
103. Nonene			
104. Ammonia Plants			
105. Other			

CODE NO.________

PORTFOLIO A (continued)

C. Description of Feedstocks Processed

	#1	#2	#3	All Others
1. Nitrogen content, %				
2. Sulfur content, %				
3. API Gravity				
4. Source (Country or U.S. geographical Region)				
5. Type (e.g. asphaltic, napthenic, paraffinic, gas)				
6. Percent of yearly crude capacity				
7. Trace metals content, %				
a. Antimony				
b. Beryllium				
c. Cadmium				
d. Chromium				
e. Copper				
f. Lead				
g. Mercury				
h. Nickel				
i. Selenium				
j. Silver				
k. Thallium				
l. Zinc				

D. Product Yield (% of 1976 Feedstock Intake)

1. Leaded gasoline ________
2. Unleaded gasoline ________
3. Naptha jet fuel ________

PORTFOLIO A (continued)

CODE NO. ________

III IN-PLANT TREATMENT

A. Crude Vacuum Unit:

1. Barometric condenser, annual average flow, MGD ____________________

B. Sour Water

1. Treated Sour Water, annual average flow, MGD ____________________

2. Method of Treatment Check Method Used

a. Single stage stripping (1) ____

b. Two stage stripping (2) ____

c. Oxidizing ____

d. Others (List)

____________________ ____

____________________ ____

____________________ ____

Annual Average Flow, MGD

3. Sour Water Sources

a. Condensate from catalytic cracking ____________________

b. Condensate from petroleum coking ____________________

c. Condensate from hydrocracking ____________________

d. Condensate from other hydroprocessing ____________________

e. Desalter water ____________________

f. Crude unit condensate ____________________

g. Flare drum knock-out ____________________

h. Other

____________________ ____________________

____________________ ____________________

____________________ ____________________

Total Sour Water Flow ____________________

4. If certain sour water streams are not treated, list them, and describe disposition (e.g. discharged, reused, etc.) ____________________

____

____

(1) Removal of hydrogen sulfide carried out by steam stripping in a single stage with or without the removal of ammonia.

(2) Removal of hydrogen sulfide and ammonia carried out separately. Hydrogen sulfide is removed in the first stage followed by ammonia removal in the second stage.

PORTFOLIO A (continued)

CODE NO.__________

III B. 5. Disposition of Treated Sour Waters — Percent

a. Desalter make-up ______

b. Other reuse (describe)

________________________________ ______

________________________________ ______

c. Non-recycled (e.g. sent to: treatment discharged, POTW, etc.) ______

6. Are sour water treatment units to be upgraded in the future? Explain and describe. Give expected completion date.

____

____

____

____

C. Spent Caustic Disposition

Annual Average Flow in Gallons per Day

1. Sulfidic

a. Amount oxidized ______________________________

b. Amount neutralized ______________________________

c. Amount sold ______________________________

d. Other, explain

__________________________ ______________________________

__________________________ ______________________________

2. Phenolic

a. Amount sold ______________________________

b. Acid oil sold ______________________________

c. Other, explain

__________________________ ______________________________

__________________________ ______________________________

D. Use the spaces below for descriptions of additional in-plant treatment systems existing at your refinery. (Attach additional sheets, if necessary).

____

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PORTFOLIO A (continued)

CODE NO.________

IV PLANT WATER MANAGEMENT

A. Intake Waters

	Annual Average Flow, MGD	Where Used (process)	Treated Prior to use? Yes/No.
1. Fresh water-river/lake			
2. Brackish or salt			
3. Well			
4. Recycled treated wastewater			
5. Municipal supply			
6. Municipal sewage effluent			
7. Rainwater			
8. Other			

9. For those intake waters treated prior to use:

a. Average total annual discharge of blowdowns from these treatment systems

b. Describe treatment systems by intake source:

B. Wastewaters

	Annual Average Flow, MGD
1. Refinery process wastewaters	
2. Ballast water	
3. Storm water treated in the main treatment system	
4. Water treatment systems blowdown	
5. Boiler blowdowns	

IV B. 6. Other wastewaters from non-refinery production operations (e.g. catalyst manufacturing). List sources and give flow rates

____ ______________

____ ______________

____ ______________

____ ______________

C. Utilities

1. Do you produce your own steam? (yes/no)________________________

2. Do you produce your own electricity? (yes/no)____________________

D. Cooling Service

1. Cooling Water Uses

Estimate your refinery's percent by volume of cooling water in each category. (Total in each category should add up to 100%.)

a. Pump Gland Cooling — Percent

(1) Closed cycle cooling system ______

(2) Once-thru segregated discharge (i.e. not in process sewer ______

(3) Once-thru non-segregated (i.e. in process sewer) ______

(4) Others (List)

________________________________ ______

________________________________ ______

Total 100%

b. Compressor Cooling

(1) Closed cycle cooling system ______

(2) Once-thru segregated discharge (i.e. not in process sewer) ______

(3) Once-thru non-segregated discharge (i.e. in process sewer) ______

(4) Others (List)

________________________________ ______

________________________________ ______

Total 100%

c. Once-Through, if applicable

(1) Segregated ______

(2) Non-segregated ______

Total 100%

PORTFOLIO A (continued)

CODE NO. ________

IV D. 2. Cooling Towers (1)	Summer	Winter
a. Source of make-up water		
b. Make-up water flow rate, MGD		
c. Make-up water quality		
(1) Chlorides, mg/l		
(2) TDS, mg/l		
(3) Sulfates, mg/l		
(4) Silica, mg/l		
(5) Hardness, as $CaCO_3$, mg/l		
d. No. of cycles of concentration		
e. Corrosion inhibitor(s) used		
(1) Type		
Concentration		
(2) Type		
Concentration		
(3) Type		
Concentration		
f. Blowdown rate, MGD		
g. Blowdown quality		
(1) Chlorides, mg/l		
(2) TDS, mg/l		
(3) Sulfates, mg/l		
(4) Hardness, as $CaCO_3$, mg/l		
h. Cooling range, Δ °F		
i. Recirculation rate, MGD		
j. Evaporation rate, MGD		

---

(1) Note: One copy of this sheet should be used for each cooling tower. Therefore, an adequate amount of copies of this sheet should be made before data is entered on the original. All copies should then be included with your response.

PORTFOLIO A (continued) CODE NO. ________

IV D. 3. Overall Summary

	Flow, MGD	% of Total Cooling (by BTU)
a. Once-through water	________	________
b. Recycled, using cooling towers or ponds	________	________
c. Air cooling	N.A.	________

E. 1. Are any wastewater flow reduction techniques planned or under construction?

a. Yes________

b. No________

2. If the answer to 1 is yes,

a. What is expected flow reduction, MGD____________________________

b. When will these changes become effective, (give date)______________

c. Describe technology planned

____

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PORTFOLIO A (continued) CODE NO.________

V **EFFLUENT DISCHARGE INFORMATION**

A. Wastewater Monitoring, Direct Dischargers and Dischargers to Publicly Owned Treatment Works.

	Sampling Frequency	Parameters Measured	Grab or Composite Sample
1. Intake Water			
a. Fresh water, river/lake			
b. Brackish or salt			
c. Well			
d. Treated wastewater - recycled			
e. Municipal supply			
f. Municipal sewage effluent			
g. Rainwater			
h. Other			
2. Discharges			
a. Main treatment plant			
b. Other non-stormwater discharged			

CODE NO.___________

PORTFOLIO A (continued)

V B. Wastewater Effluent Limitations - Direct Dischargers (NPDES Values) and Dischargers to Publicly Owned Treatment Works. (Pretreatment Limitations)

Final July 1, 1977 - BPT Limitations (in pounds and/or concentration units - give units) for main wastewater treatment system.

1. Parameter	a. Daily Average	b. Daily Maximum	c.Other	d.Dec. 1975 DMR* Daily Avg. Values	e.Dec. 1976 DMR* Daily Avg. Values
(1) Oil & Grease					
(2) BOD					
(3) COD					
(4) TOC					
(5) TSS					
(6) Phenolic Compounds					
(7) Chromium, Total					
(8) Chromium, Hex.					
(9) Ammonia					
(10)Sulfides					
(11)Others					
(12)					
(13)					

* EPA Discharge Monitoring Report Form

CODE NO._________

V C. Additional Information

1. If your refinery is a direct discharger, please give your:
   - a. NPDES permit number______________________________
   - b. NPDES permit expiration date__________________________
   - c. Refuse Act/NPDES application number____________________
   - d. Permitting authority receiving compliance data_______________

     ____
   - e. Give process configuration factor* used for permit development

     ____
2. Are wastewaters discharged to the same water body used for process intake waters? If yes, are discharges upstream or downstream of process intake waters?
   - a. Yes________ Up________ Down________
   - b. No________
   - c. If yes, which wastewaters?

     ____

     ____

     ____
3. Are "net discharge" values used in the NPDES permit limitations?
   - a. Yes________
   - b. No________
4. If your refinery is an indirect discharger, please give name of the municipal sewage authority receiving your wastewater.__________________

   ____

   ____

   ____

*Ref: Federal Register (40 CFR Part 419)

VI WASTEWATER TREATMENT

A. Attached is a block diagram showing most of the effluent treatment unit operations utilized in oil refineries. Please use this diagram to indicate those treatment processes used in your facility. Use lines with arrows to explain your refinery system. For clarity, cross out those boxes not applicable. Join all other boxes with lines indicating system connections. In addition, please include any available flow diagrams that can supplement this information.

B. Additional Clarifications

Please use the following page to present a narrative that will supplement the attached block flow diagram. This narrative should include a sequential listing of the applicable waste treatment processes, including flow rates where available and number and letter designations, as listed on the block diagram. The narrative should also present clarifications where the block diagram cannot adequately describe your system. Also describe all processes indicated as "other" on flow diagram.

An example of a typical response is as follows:

Intake water

I. Water from Lake Michigan (1.a.) is used for segregated, once-thru cooling (2.a.) at a rate of 3.0 MGD.

II. Water from a municipal supply (1.e.) goes to all process uses (0.8 MGD). Other miscellaneous uses of municipal supply total 0.02 MGD.

Industrial wastewater

I. Segregated, once-thru cooling water (2.a.) is discharged directly (3.0 MGD) to Lake Michigan (9.b.).

II. Boiler blowdown (2.d.) at 0.04 MGD, blowdown from water treatment system (2.j.) at 0.03 MGD, sour water (2.i.) at 0.02 MGD, and contaminated runoff (2.g.) go to one API separator (4.b.).

III. Oily process water (2.e.) at 0.02 MGD and ballast water (2.f.) are discharged to another API separator (4.c.).

All wastewater from the two API separators are then combined in an equalization basin (5.e.), fed to a dissolved air flotation unit (6.b.), and discharged to a stabilization pond (7.d.).

Sanitary sewage (0.02 MGD) is treated in an activated sludge unit (10.b.), and then pumped to the stabilization pond (7.d.).

Effluent from the pond is discharged directly to Lake Michigan (9.b.) at a rate of 1.30 MGD.

PORTFOLIO A (continued)

CODE NO.________

VI A. WASTEWATER TREATMENT FLOW DIAGRAM

1. Intake Water
   - a. Fresh Water - River or Lake
   - b. Brackish or Salt Water
   - c. Well Water
   - d. Treated Waste Water - Recycled
   - e. Municipal Supply
   - f. Municipal Sewage Effluent
   - g. Rainwater
   - h. Other

2. Industrial Wastewater
   - a. Segregated Once-Thru Cooling Water
   - b. Non-Segregated Once-Thru Cooling Water
   - c. Cooling Tower Blowdown
   - d. Boiler Blowdown
   - e. Oily Process Water
   - f. Ballast Water
   - g. Contaminated Runoff
   - h. Uncontaminated Runoff
   - i. Sour Water
   - j. Water Treat. Systems Blowdown
   - k. Other

3. Intermediate Treatment
   - a. pH Adjustment
   - b. Aeration
   - c. Chlorination
   - d. Other Oxidizing Process
   - e. Equalization
   - f. Other

4. Primary Separation
   - a. Retention Pond
   - b. API Separator
   - c. PPI Separator
   - d. TPI Separator
   - e. Corrugated Plate Interceptor
   - f. Oil Skimmer
   - g. Other

5. Intermediate Treatment
   - a. pH Adjustment
   - b. Aeration
   - c. Chlorination
   - d. Other Oxidizing Process
   - e. Equalization
   - f. Other

6. Additional Oil & Solids Removal
   - a. Chemical Flocculation
   - b. DAF
   - c. Other Flot. System (DGF, IAF)
   - d. Filtration
   - e. Clarification
   - f. Other

7. Organics Removal
   - a. Activated Sludge
   - b. Trickling Filter
   - c. Aerated Lagoon
   - d. Stabilization Pond Without Aerators
   - e. Activated Carbon
   - f. Bio-Discs
   - g. Other

8. Final Polishing
   - a. Ponding
   - b. Filtration
   - c. Chlorination
   - d. Activated Carbon
   - e. Clarification
   - f. Other

9. Final Disposition
   - a. River
   - b. Lake
   - c. Salt Water
   - d. Brackish Water
   - e. City Sewer
   - f. Evap. or Percolation Pond
   - g. Disposal Well
   - h. Canal
   - i. Contract Disposal
   - j. Other

10. Sanitary Sewage Treatment
   - a. Septic Tank
   - b. Activated Sludge
   - c. Trickling Filter
   - d. Aerated Lagoon
   - e. Ind. Treat. Plant
   - f. City Sewer
   - g. Other

Average Detention Time for Each Unit Operation ________ ________ ________ ________ ________ ________

CODE NO.________

VI B. Additional Clarifications

CODE NO. ________

VI C. Future Modifications

Please use the following spaces to describe wastewater treatment plant modifications presently under construction or planned for the future. Include flow rates, detention times, and expected operational dates. In addition, please use the code numbers on the block diagram in your description.

CODE NO.________

PETROLEUM REFINING INDUSTRY SURVEY

FOR REVISION OF "BEST AVAILABLE TECHNOLOGY" (BAT) EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS

PORTFOLIO B

NOTES

(1) Portfolio B is to be mailed within 60 days of receipt to:

Robert B. Schaffer, Director
Effluent Guidelines Division
U.S. Environmental Protection Agency (WH-552)
Washington, D.C. 20460

I GENERAL INFORMATION

A. Name of Refinery____

B. Street Address____

____

____

C. Refinery Contact____

D. Telephone Number____

II ADDITIONAL POLLUTANT INFORMATION

Part of our scope of work, as specified in the U.S. District Court settlement agreement of June 7, 1976 (8 E.R.C 2120 D.D.C. 1976), requires that we obtain analytical data and other information on the presence and removal of the priority pollutants included in Table IIA. The questions listed in this portfolio are general in nature, and are meant to serve as a guide for future contacts to obtain more detailed information.

CODE NO. ________

II 6. Please fill in the table below, showing what information your refinery has available on the listed priority pollutants. Give yes answers where applicable.

Note: Synonyms (syn) and trade names (trd) are from the Oil & Hazardous Materials - Technical Assistance Data System of the Oil & Special Materials Control Division, U.S.E.P.A.

	Toxic Substances	Chemicals purchased as a raw or intermediate material	Chemicals manufactured as a final or intermediate material	Chemicals for which you have analyzed in wastewater	Frequency or number of times analyzed
1.	acenaphthene				
2.	acrolein syn: 2-propenal, acrylic-aldehyde, acrylaldehyde, acraldehyde trd: Aqualin, Aqualin-biocide, Aqualin-slimicide				
3.	acrylonitrile syn: propenenitrile, vinyl-cyanide, cyano-ethylene trd: Fumigrain (Thompson-Hayward), Ventox				
4.	aldrin syn: octalene, compound 118, trd: HHDN				
5.	dieldrin syn: compound 497, octalox, alvit, quintox				
6.	benzene syn: benzol, cyclohexatriene				
7.	benzidine				
8.	carbon tetrachloride syn: methane tetrachloride, tetrachloromethane, perchloromethane, necatorine, benzinoform trd: Necatorine, Benzinoform				
9.	chlordane syn: Velsicol-1068, CD-68, toxichlor, octa-klor trd: Ortho-klor (Chevron), Velsicol-1068 (Velsicol) Oct-Klor (Dow)				
10.	chlorobenzene syn: monochloro-benzene, benzene-chloride, phenyl-chloride				
11.	1,2,4-trichlorobenzene				
12.	hexachlorobenzene				
13.	1,2-dichloroethane				
14.	1,1,1-trichloroethane				
15.	hexachloroethane				
16.	1,1-dichloroethane				
17.	1,1,2-trichloroethane				
18.	1,1,2,2-tetrachloroethane				
19.	chloroethane				
20.	bis(chloromethyl) ether				
21.	bis(2-chloroethyl) ether				
22.	2-chloroethyl vinyl ether				
23.	2-chloronaphthalene				
24.	2,4,6-trichlorophenol				
25.	p-chloro-m-cresol				
26.	chloroform syn: trichloromethane				
27.	2-chlorophenol				
28.	4,4'-DDT				
29.	4,4'-DDE				
30.	4,4'-DDD syn: p,p'-TDE				
31.	1,2-dichlorobenzene				
32.	1,3-dichlorobenzene				
33.	1,4-dichlorobenzene				
34.	3,3'-dichlorobenzidine				
35.	1,1-dichloroethylene				
36.	1,2-trans-dichloroethylene				
37.	2,4-dichlorophenol				
38.	1,2-dichloropropane				
39.	1,3-dichloropropylene syn: 1,3-dichloropropene				
40.	2,4-dimethyl phenol				
41.	2,4-dinitrotoluene				

CODE NO.______

Toxic Substances	Chemicals purchased as a raw or intermediate material	Chemicals manufactured as a final or intermediate material	Chemicals for which you have analyzed in wastewater	Frequency or number of times analyzed
42. 2,6-dinitrotoluene				
43. 1,2-diphenylhydrazine				
44. "a"-endosulfan				
45. "b"-endosulfan				
46. endosulfan sulfate				
47. endrin syn: compound -269, mendrin				
48. endrin aldehyde				
49. asbestos				
50. ethylbenzene syn: phenylethane				
51. fluoranthene				
52. 4-chlorophenyl phenyl ether syn: p-chloro-diphenyl ether				
53. 4-bromophenyl phenyl ether				
54. bis(2-chloroisopropyl)ether				
55. bis(2-chloroethoxy) methane				
56. methylene chloride syn: methane dichloride, dichloromethane, methylene bichloride, methylene dichloride trd: Solaesthin				
57. methyl chloride syn: chloromethane, monochloromethane				
58. methyl bromide syn: brom-o-gas, bromomethane, [illegible], metafume, [illegible], iscobrome trd: Dytox, Profume, Rotox, Embafume, Dowfume MC-33, Dowfume MC-2, Celfume, Metafume				
59. bromoform syn: tribromomethane				
60. dichlorobromomethane				
61. trichlorofluoromethane syn: trichloromonofluoromethane, fluorotrichloromethane, freon-11 arcton-9, fluorocarbon-11 trd: Genetron (Allied), Isotron (Pennwalt), Freon (DuPont), Racon (Racon), Ucon (Union Carbide)				
62. dichlorodifluoromethane syn: fluorocarbon-12, genetron-12, freon-12				
63. chlorodibromomethane				
64. heptachlor syn: Velsicol-104, heptagran, drinox				
65. heptachlor epoxide				
66. hexachlorobutadiene				
67. "a"-BHC				
68. "b"-BHC				
69. γ -BHC syn: lindane				
70. δ-BHC				
71. hexachlorocyclopentadiene				
72. isophorone				
73. naphthalene syn: napthalin, napthene, tarcamphor, white-tar				
74. nitrobenzene				
75. 2-nitrophenol				
76. 4-nitrophenol				
77. 2,4-dinitrophenol syn: a-dinitrophenol, aldifen				
78. 4,6-dinitro-o-cresol				
79. N-nitrosodimethylamine				
80. N-nitrosodi-n-propylamine				
81. N-nitrosodiphenylamine				
82. pentachlorophenol syn: penta, santophen-20, PCP trd: Dowicide-G (Dow), Dowicide-7 (Dow)				

CASE NO.________

Toxic Substances	Chemicals purchased as a raw or intermediate material	Chemicals manufactured as a final or intermediate material	Chemicals for which you have analyzed in wastewater	Frequency or number of times analyzed
83. phenol syn: carbolic-acid, phenylic-acid, phenyl-hydroxide, phenic-acid				
84. bis(2-ethylhexyl) phthalate				
85. butyl benzyl phthalate syn: phthalic acid, benzyl butyl ester, benzyl butyl phthalate trd: Santicizer 160 (Monsanto)				
86. di-n-butyl phthalate				
87. diethyl phthalate				
88. dimethyl phthalate				
89. PCB-1242 trd: Arochlor 1242				
90. PCB-1254 trd: Arochlor 1254				
91. 1,2-benzanthracene				
92. benzo (a)pyrene syn: 3,4-benzopyrene				
93. 3,4-benzofluoranthene				
94. 11,12-benzofluoranthene				
95. chrysene				
96. acenaphthylene				
97. anthracene				
98. 1,12-benzoperylene				
99. fluorene				
100. phenanthrene				
101. 1,2:5,6-dibenzanthracene				
102. indeno (1,2,3-C,D)pyrene				
103. pyrene				
104. 2,3,7,8-tetrachlorodibenzo-p-dioxin syn: TCDD				
105. tetrachloroethylene				
106. toluene syn: toluol, methyl-benzene, methacide phenylmethane, toluol				
107. toxaphene syn: compound-3956, alltex, geniphene, toxakil, toxadust, phenacide, penphene, chlorinated-camphene trd: Phenacon				
108. trichloroethylene syn: trichloroethene, tri-clene, triclene, trilene, trichloran, trichloren, algylen, trimar, triline, tri, trethylen, trethylene, westrosol, chlorylen, gemalgene, germalgene				
109. vinyl chloride syn: chloroethylene, chloroethene				
110. antimony and compounds				
111. arsenic and compounds				
112. zinc and compounds				
113. beryllium				
114. cadmium and compounds				
115. chromium and compounds				
116. copper and compounds				
117. cyanides				
118. lead and compounds				
119. mercury and compounds				
120. nickel and compounds				
121. selenium and compounds				
122. silver and compounds				
.23. thallium and compounds				

CODE NO.__________

II B. Priority Pollutant #_________________________

Priority Pollutant Name_____________________

Directions: For each substance that you have analyzed for in wastewater (i.e. for each substance checked in Column 3 in Table IIA) please fill out one copy of this page. DUPLICATE THIS SHEET FOR EACH SUBSTANCE AS REQUIRED BEFORE ENTERING ANY INFORMATION ON THE ORIGINAL.

Please indicate yes/no to the following questions:

a. Is plant data available on the removal efficiency by biological treatment for this substance?_______________

b. If yes, please indicate treatment type, e.g. bench scale, pilot, or full scale.
____

c. Is plant data available on the removal efficiency by sorption type treatment systems (e.g. carbon, clay, sludge, etc.) for this substance?________________

d. If yes, please indicate treatment type, e.g. bench scale, pilot, or full scale.
____

e. Is plant data available on the removal efficiency of this substance by air or steam stripping processes (or any system which includes removal to the atmosphere, e.g. DAF)?__________________

f. If yes, please indicate treatment type, e.g. bench scale, pilot, or full scale.
____

g. Is plant data available on the removal efficiency by solvent extraction processes for this substance?___________

h. If yes, please indicate treatment type, e.g. bench scale, pilot, or full scale.
____

i. Is plant data available on the removal efficiency by any other process for this substance?____________________ Specify process________________________________

j. If yes, please indicate treatment type, e.g. bench scale, pilot, or full scale.
____

k. Is plant data available regarding health affects (acute or chronic) of this substance?____________________

l. Specify the analytical procedure(s) utilized for measuring this substance in wastewater____
____
____
____
____

m. Is plant data available correlating the removal of this substance with the removal of BOD, TOC, COD, or any other typical pollutant?________________

Plant Contact for further information____

Contact's Telephone Number____

Supplemental Flow Question

SUPPLEMENTAL FLOW QUESTION

The following data request does not relate to economics directly, but is added here because of comments made by the American Petroleum Institute that your responses to Question IV.B.of Portfolio "A" of the 1977 Petroleum Refining Industry Survey need further clarification. This is a follow-up to the original 308 questionnaire sent to refineries in February or August of 1977 by Mr. Robert B. Schaffer, Director of the Effluent Guidelines Division.

Please submit your completed response (page 3) within 14 days to:

Robert W. Dellinger (WH-552)
Effluent Guidelines Division
U.S. Environmental Protection Agency
401 M. Street S.W.
Washington, D.C. 20460

Wastewater Discharge Data

The attached figure includes a block flow diagram depicting various possible wastewater flows present at petroleum refineries. Please fill in the annual average dry weather flow, for calendar year 1976, for each flow line applicable to your refinery. Do not supply additional data sheets. The units for these flow rates should be presented in million gallons per day only. If your refinery has multiple streams of each type, the total of these streams should be used; i.e., assume your system is similar to the simplified block flow diagram attached.

Excluded Selected Wastewaters

It should be noted that the flow rates asked for may not correspond to actual streams in the refineries. For example, the physical influent to your end-of-pipe treatment system may include storm water or ballast water. However, the flow rates to be reported should not include storm water, ballast water, sanitary wastewater, once-through non-contact cooling water, other non-refinery related wastewater, nor any raw (untreated) wastewater reused within the refinery complex.

The following definitions apply to each flow line:

1. Total Refinery Wastewater Excluding Selected Wastewaters - Excluding the selected wastewaters above, this "flow line" includes non-segregated cooling water, cooling tower blowdown, boiler blowdown, oily process water, sour water, water treatment system blowdown and "other refinery-related wastewaters". It includes all of the above mentioned wastewaters regardless of disposition.

Oily process water by implication includes all wastewaters generated at the refinery and which are not covered under any other above-mentioned specific categories (i.e., sour water). Oily process water includes, but is not limited to, such wastewaters as contact process water, non-sour process condensates, vent scrubber water, tank drains, flare seal water blowdown, laboratory drains, maintenance shop drains, hydrotest waters, maintenance decontamination waters, pad wash waters, fire waters and system test waters, and barometric condenser water blowdowns. The above "other refinery-related wastewaters" would include, but are not limited to, wastewaters from blowdown from air pollution control equipment and wastewaters originating at the wastewater treatment plant. Additionally, this stream is based on net flow and includes each wastewater only once. For example, if the sour water stripper blowdown is used in the desalter then only the desalter water would be included to avoid double accounting the sour water.

2. Untreated Refinery Wastewaters Excluding Selected Wastewaters to POTW Excluding the selected wastewaters listed on page 1, this flow line includes untreated (by an EOPS) refinery wastewater that is discharged to a POTW (Publicly Owned Treatment Works). For the purpose of this survey , oil/water separation is considered an end-of-pipe treatment but sour water stripping is not.

3. Untreated Refinery Wastewater Excluding Selected Wastewaters to Other Disposal - Excluding the selected wastewaters listed on page 1, this flow line includes untreated (by EOPS) refinery wastewater that is not disposed of via an NPDES permit, nor discharged to a POTW. This type of discharge includes deep well disposal, land application, contract disposal, evaporation, percolation, etc.

4. Wastewater Treatment Influent Excluding Selected Wastewaters - Excluding the selected wastewaters listed on page 1, this flow line includes the dry weather refinery wastewater flow which receives end-of-pipe treatment. Please note that flow line 4 should equal flow line 1 less flow lines 2 and 3.

5. Recycled Treated Wastewater Excluding Selected Wastewaters - Excluding the selected wastewaters listed on page 1, this flow line includes that portion of the dry weather, end-of-pipe treatment effluent that is recycled for use in refinery operations.

6. Treated Wastewater Excluding Selected Wastewaters to POTW - Excluding the selected wastewaters listed on page 1, this flow line includes that portion of the dry weather, end-of-pipe treatment effluent which is discharged to a POTW.

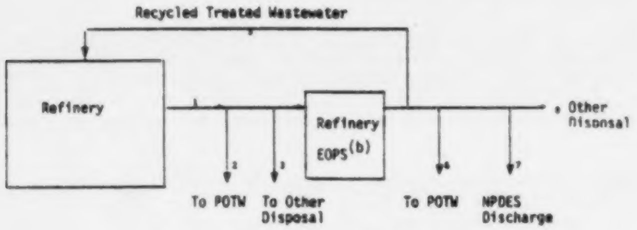
7. NPDES Discharge Excluding Selected Wastewaters - Excluding the selected wastewaters listed on page 1, this flow line includes that portion of the dry weather end-of-pipe treatment effluent which is a direct discharge under an NPDES permit.

8. Treated Wastewater Excluding Selected Wastewaters to Other Disposal - Excluding the selected wastewaters listed on page 1, this flow line includes that portion of the dry weather, end-of-pipe treatment effluent which is not covered in flow lines 6 and 7. This type of disposal includes deep well injection, land application, contract disposal, evaporation, percolation, etc.

Please review the attached example, which is given in two steps, before answering the questions. Step 1 (pages 4 and 5) is a calculation of required flow rates and Step 2 (page 6) is essentially the example summary answer sheet that upon completion would be transmitted back to EPA.

NOTE: The main purpose of the attached example is to clarify the above definitions. In Step 2 of the example it may become apparent that only certain flows are needed to determine the required flow rates. It should be noted that the calculation procedure would vary from refinery to refinery because the required flow rates could be obtained by either additions or subtractions of various required flows. Thus for each refinery one should determine what flows are required to answer the given questions. We do not require that you submit your work sheets; you need only submit the completed summary page (page 3).

Refinery Name________________________ Location________________________
(city, state)



Flow Line Number	Flow Line Identification [a]	Annual Average Dry Weather Flow Calendar Year 1976 [d] (million gallons/day)	Flow Basis [c]
1	Total Refinery Wastewater Excluding Selected Wastewaters	________	________
2	Untreated Production Wastewater Excluding Selected Wastewaters to POTW	________	________
3	Untreated Refinery Wastewater Excluding Selected Wastewaters to Other Disposal	________	________
	Specify Other Disposal__________		
4	Wastewater Treatment Influent Excluding Selected Wastewaters	________	________
5	Recycled Treated Wastewater Excluding Selected Wastewaters	________	________
6	Treated Wastewater Excluding Selected Wastewaters to POTW	________	________
7	NPDES Discharge Excluding Selected Wastewaters	________	________
8	Treated Wastewater Excluding Selected Wastewaters to Other Disposal	________	________
	Specify Other Disposal__________		

In addition, please indicate the source and flow rate for pump gland cooling water ________ ________

Source________________________

(a) These flow lines are as defined in the narrative.
(b) Refinery EOPS refers to any end-of-pipe wastewater treatment system (including oil water separation).
(c) Indicate whether flow value is measured, estimated, or calculated (To be considered a calculated flow, the calculation must be based on all measured flows.).
(d) Please fill in all flow lines; i.e., indicate zeros where applicable.

EXAMPLE

Step 1 Calculation of Wastewater Flows at XYZ Refining Company:

Flow Line Identification	Wastewater Included or Excluded		Annual Average Dry Weather Calendar Year 1976 Flow, Million Gallons per Day
1. Total refinery wastewater excluding selected wastewaters	Total wastewater influent to EOPS		5.97 (M)[1]
	Ballast water		-0.05 (M)
	Storm water[4]		-0.02 (E)[2]
	Untreated refinery wastewaters to a POTW		+0.9 (M)
	Untreated refinery wastewater to other disposal		+0.303 (M)
		Total	7.103 (E)
2. Untreated refinery wastewaters excluding selected wastewaters to a POTW	Boiler blowdowns		0.2 (M)
	Water treatment systems blowdown		0.7 (M)
		Total	0.9 (C)[3]
3. Untreated refinery wastewater excluding selected wastewaters to other disposal	Spent caustic wastewaters		0.003 (M)
	Air pollution control equipment blowdowns		0.3 (M)
		Total	0.303 (M)
4. Wastewater treatment influent excluding selected wastewaters	Total wastewater treatment influent		5.97 (M)
	Ballast water		-0.05 (M)
	Storm water		-0.02 (E)
		Total	5.90 (E)
Wastewater Balance	Flow Lines		
	1		7.103
	-2		-0.9
	-3		-0.303
	-4		-5.9
	Difference should equal 0.0		0.0

1/ Measured
2/ Estimated
3/ Calculated based on measured flows
4/ If dry weather flows are known, storm water contributions can be ignored.

Step 1 Calculation of Wastewater flows at XYZ Refining Company (continued)

Flow Line Identification	Wastewater Included or Excluded		Annual Average Dry Weather Calendar Year 1976 Flow, Million Gallons per Day
5. Recycled wastewater excluding selected wastewaters	Recycled treated wastewaters		1.98 (E)[1]
6. Treated wastewater excluding selected wastewaters to POTW	Treated wastewaters discharged to a POTW		0.0
7. NPDES Discharge excluding selected wastewaters	Total wastewater discharged to stream Ballast water plus storm water	Total	3.97 (M) - .047 (E)[2] 3.92 (E)
8. Treated wastewater, excluding selected wastewaters to other disposal	Other disposal of treated wastewaters		0.0

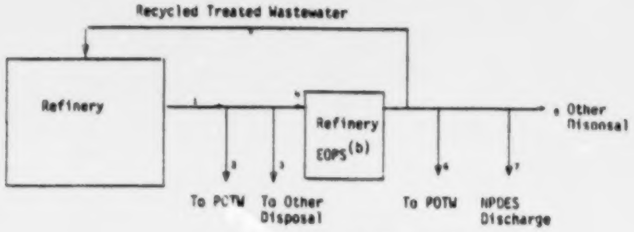
Wastewater Balance	Flow Lines	
	5	1.98
	+6	+0.0
	+7	+3.92
	+8	+0.0
	Total	+5.9
	-4	-5.9
	Difference should be close to 0.0	0.0

(May not be exactly 0.0 because of losses in EOPS, such as blowdowns and evaporation)

1/ A measured flow of 2.0 million gallons of treated effluent is recycled per day. Some storm water and ballast water are recycled with the treated effluent. This equals (2.0/5.97)(0.05 + 0.02) = .0235 million gallons per day. Therefore, the estimated value of 2.0 - .0235 or 1.98 is shown. If dry weather flows are known, and no ballast water is discharged to the treatment system, this calculation is unnecessary.

2/ Based on calculation of that portion of ballast and storm water that is recycled. Ballast water plus storm water equals 0.07 - 0.0235 = 0.0465 or 0.047.

Refinery Name XYZ Refining Co. EXAMPLE Location Boston, Mass.
(city, state)



Flow Line Number	Flow Line Identification (a)	Annual Average Dry Weather Flow Calendar Year 1976(d) (million gallons/day)	Flow Basis(c)
1	Total Refinery Wastewater Excluding Selected Wastewaters	7.103	Estimated (checked by Balance)
2	Untreated Production Wastewater Excluding Selected Wastewaters to POTW	0.9	Calculated
3	Untreated Refinery Wastewater Excluding Selected Wastewaters to Other Disposal Specify Other Disposal deep-well	0.303	Measured
4	Wastewater Treatment Influent Excluding Selected Wastewaters	5.9	Estimated
5	Recycled Treated Wastewater Excluding Selected Wastewaters	1.98	Estimated*
6	Treated Wastewater Excluding Selected Wastewaters to POTW	0.0	—
7	NPDES Discharge Excluding Selected Wastewaters	3.92	Estimated
8	Treated Wastewater Excluding Selected Wastewaters to Other Disposal Specify Other Disposal —	0.0	—

In addition, please indicate the source and flow rate for pump gland cooling water 1.0 Estimated

Source Mainly treated river water.

(a) These flow lines are as defined in the narrative.
(b) Refinery EOPS refers to any end-of-pipe wastewater treatment system (including oil water separation).
(c) Indicate whether flow value is measured, estimated, or calculated (To be considered a calculated flow, the calculation must be based on all measured flows.).
(d) Please fill in all flow lines; i.e., indicate zeros where applicable.

* Measured flow is 2.0 million gallons/day. Subtracting ballast + storm water in recycle yields 1.98 million gallons/day.

APPENDIX 2

EPA Regional Surveillance and Analysis

Sampling Survey, Analytical Results for Priority Pollutants

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EPA REGIONAL SURVEILLANCE AND ANALYSIS SAMPLING SURVEYS
ANALYTICAL RESULTS FOR PRIORITY POLLUTANTS*
(Concentrations in ug/l)

Refinery 1

A. Intake water (all Day 1 grab samples)

1. Volatile organics

a	Preserved:	chloroform	29
b.	Unpreserved:	chloroform	53
		methylene chloride	L 10[1]

2. Semivolatile organics: not detected

3. Metals:

antimony	L 5	lead	L 5
arsenic	L 5	nickel	L 5
beryllium	L 5	selenium	L 5
cadmium	L 10	silver	L 5
chromium	L 5	thallium	L 1
copper	L 10	zinc	L 10

4.	Phenolics	L 5
5.	Cyanide:	L 2
6.	Mercury:	L 0.5
7.	Asbestos:	not sampled

B. Wastewater treatment system influent

1. Volatile organics (Day 1 grab sample/Day 2 grab sample)

a.	Preserved:	benzene	NA[2]/165
		ethylbenzene	NA/L 10
		methylene chloride	NA/L 10
		toluene	NA/L 10
		vinyl chloride	NA/L 10
b.	Unpreserved:	benzene	27/230
		1,1,2,2,-tetrachloroethane	L 10/ND[3]
		chloroform	L 10/L 10
		1,2-trans-dichloroethylene	L 10/L 10
		ethylbenzene	L 10/17
		methylene chloride	32/ND
		tetrachloroethylene	L 10/14
		toluene	43/180

(1) L - Less than
(2) NA - Not analyzed
(3) ND - Not detected

* Sampling and analysis conducted for volatile organics, semivolatile organics and metals as listed on Table III-4, unless noted. Only detected priority pollutants are reported.

2. **Semivolatile organics:** (48 hour composite sample/blank)

acenaphthene	11/ND
naphthalene	47/ND
phenol	37/ND
bis(2-ethylhexyl) phthalate	17/ND

3. **Metals:** (48 hour composite sample/blank)

antimony	L 5/L 5	lead	46/L 5
arsenic	L 5/L 5	nickel	L 5/L 5
beryllium	L 5/L 5	selenium	L 5/L 5
cadmium	L 10/L 10	silver	L 5/L 5
chromium	L 5/L 5	thallium	L 8/L 1
copper	14/L 10	zinc	130/L 10

4. **Phenolics:** 37
(composite of 2 daily grab samples)

5. **Cyanide:** L 2
(composite of 2 daily grab samples)

6. **Mercury:** 2/L 0.5
(48 hour composite sample/blank)

7. **Asbestos:** not sampled

C. Wastewater treatment system effluent

1. Volatile organics (Day 1 grab sample/duplicate/blank)

a. **Preserved:** methylene chloride L 10/L 10/L 10

b. **Unpreserved:** methylene chloride L 10/L 10/L 10

Volatile organics (Day 2 grab sample/duplicate)

c. **Preserved:** methylene chloride L 10/L 10
toluene ND/L 10

d. **Unpreserved:** methylene chloride L 10/L 10

2. **Semivolatile organics:** (48 hour composite sample)[4]

bis(2-ethylhexyl) phthalate	11
phenol	76

---

(4) Sample bottle containing blank for semivolatile organics was broken and contents were lost.

3. **Metals:** (48 hour composite sample/blank)

antimony	L 5/L 5	lead	12/L 5
arsenic	L 5/L 5	nickel	L 5/L 5
beryllium	L 5/L 5	selenium	L 5/L 5
cadmium	L 10/L 10	silver	L 5/L 5
chromium	L 5/L 5	thallium	L 10/L 1
copper	L 10/L 10	zinc	19/L 10

4. Phenolics 113
(composite of 2 daily grab samples)

5. Cyanide: 3
(composite of 2 daily grab samples)

6. Mercury: L 0.5/L 0.5
(48 hour composite sample/blank)

7. Asbestos: not sampled

Refinery 83

A. Sour water stripper influent (all Day 1 grab samples)

1. Volatile organics

benzene	G 4840[5]
toluene	G 7000
ethylbenzene	3030

2. Semivolatile organics

phenol	42000
2,4 Dimethylphenol	100
naphthalene	5410
bis(2-ethylhexyl)phthalate	L 50
fluorene	L 50
phenanthrene and/or anthracene	210
di-n-butyl-phthalate	L 50

3. Metals

copper	70.0[6]
silver	8.1
zinc	70.0

4. Phenolics	NA
5. Cyanide	14
6. Mercury	2
7. Asbestos	not sampled

B. Sour water stripper effluent (all Day 1 grab samples)

1. Volatile organics

benzene	G 4840
toluene	G 7000
ethyl benzene	1750

2. Semivolatile organics

phenol	7000
2,4-dimethylphenol	230
naphthalene	700
bis(2-ethylhexyl)phthalate	L 100
acenaphthene	L 100
fluorene	L 100
phenanthrene and/or anthracene	700
di-n-butyl-phthalate	L 100

(5) G x - Detected greater than x

(6) Values for copper should be viewed with caution due to new piping on sample tap.

3. Metals[7]

cadmium	1
chromium	11
copper	150
lead	130
zinc	630
arsenic	50

4. Phenolics	NA
5. Cyanide	120
6. Mercury	ND
7. Asbestos	not sampled

C. Intake water #1 (all Day 1 grab samples)[8]

1. Volatile organics	ND

2. Semivolatile organics (grab sample/duplicate/blank)

bis(2-ethylhexyl)phthalate	10/40/L 10
di-n-butyl-phthalate	L 10/L 10/ND

3. Metals

zinc	7

4. Phenolics	13
5. Cyanide	ND
6. Mercury	0.7
7. Asbestos	not sampled

D. Intake water #2 (all Day 1 grab samples)[9]

1. Volatile organics (grab sample #1/duplicate)

methylene chloride	L 10/L 10
chloroform	150/80
bromodichloromethane	30/20
dibromochloromethane	L 10/L 10

2. Semivolatile organics (grab sample)

bis(2-ethylhexyl)phthalate	10
di-n-butyl-phthalate	L 10

(7) Values for metals should be viewed with caution due to new copper line on sample tap, with cadmium, brass and galvanized fittings.

(8) Well water intake.

(9) Municipal water intake.

3. Metals

copper	30
zinc	80

4. Phenolics ND

5. Cyanide NA

6. Mercury 0.4

7. Asbestos not sampled

E. Wastewater treatment system influent

1. Volatile Organics (Day 1 grab sample/Day 2 grab sample)

chloroform	10/10
bromodichloromethane	L 10/L 10
trans-1,3-Dichloropropene	10/10
toluene	340/430
ethylbenzene	20/20

2. Semivolatile organics (Day 1, 24 hour composite samples)

phenol	910
chlorophenol	50
2,4-dichlorophenol	L 10
pentachlorophenol	40
naphthalene	230
bis(2-ethylhexyl)phthalate	L 100
fluorene	L 100

3. Metals (Day 1/Day 2 grab samples - Day 1/Day 2, 24 hour composite samples)

chromium (hex)	NA/138-55/98
copper	NA/40-130/30
lead	NA/6-27/18
zinc	NA/480-1700/530
arsenic	NA/NA-35/ND
cadmium	NA/NA-1.7/1.2
chromium (total)	NA/2600-3600/1200

4. Phenolics (Day 1/Day 2 grab sample) 11700/6050

5. Cyanide
(Day 1 grab sample/Day 2 grab sample) 16/36

6. Mercury (Day 2 grab sample) 0.6

7. Asbestos not sampled

F. Wastewater treatment system effluent

1. Volatile Organics (Day 1 grab sample/Day 2 grab sample)

methylene chloride	L 10/ND
chloroform	L 10/L 10
toluene	L 5/L 5

2. Semivolatile Organics (Day 1, 24 hour composite samples)

2,4 dimethylphenol	L 10
pentachlorophenol	L 20
bis(2-ethylhexyl)phthalate	L 10
fluorene	L 10
phenanthrene and/or anthracene	80
di-n-butyl-phthalate	L 10

3. Metals (Day 1, 24 hour composite sample/Day 2, 24 hour composite sample/Day 2 grab sample)

chromium	320/370/480
copper	20/ND/20
lead	6/ND/ND
zinc	570/480/620

4. Phenolics (Day 1 grab sample/Day 2 grab sample	75/125
5. Cyanide (Day 1 grab sample/Day 2 grab sample)	8/3
6. Mercury (Day 2 grab sample)	0.5
7. Asbestos	not sampled

Refinery 131

A. Intake water #1[10] (all grab samples)

1. Volatile organics

1,1,1-trichloroethane	6.2
chloroform	11.6
1,2-transdichlorethylene	47.0
ethylbenzene	0.3
methylene chloride	0.3
dichlorobromomethane	3.5
chlorodibromomethane	1.0
tetrachloroethylene	0.3
toluene	0.02
trichloroethylene	0.03

2. Semivolatile organics[11]

bis(2-ethylhexyl)phthalate	2.8

3. Metals

copper	6.0
lead	0.6
nickel	0.1
zinc	250.0

4. Phenolics	9.5
5. Cyanide	ND
6. Mercury	ND
7. Asbestos	not sampled

B. Intake water #2[12] (all grab samples)

1. Volatile organics

1,1,1-trichlorethane	2.0
1,1-dichloroethylene	0.7
ethylbenzene	0.1
methylene chloride	3.7

2. Semivolatile organics	ND

(10) Municipal water intake. 9% of total intake flow.

(11) Sample blanks at Refinery 131 analyzed for all semivolatile organic samples. No parameters detected for sample blank analysis.

(12) Well water intake. 1% of total intake flow.

3. Metals

antimony	4.5
beryllium	0.5^{14}
copper	7.0
lead	12.0
nickel	1.0
zinc	7.0

4. Phenolics	ND
5. Cyanide	ND
6. Mercury	0.3
7. Asbestos	not sampled

C. Intake water #3[13]

1. Volatile organics (grab samples)

chlorobenzene	0.05
1,2-dichloroethane	2.10
1,1,1-trichlorethane	2.60
chloroform	15.30
1,1-dichloroethylene	0.10
methylene chloride	27.00
bromoform	0.80
tetrachloroethylene	2.30
trichloroethylene	2.30

2. Semivolatile organics (24 hour composite samples)

bis(2-ethylhexyl)phthalate	35

3. Metals

antimony	100
beryllium	4^{14}
cadmium	10
chromium	61
copper	59
lead	180
nickel	54
zinc	130

4. Phenolics (grab sample)	8.6
5. Cyanide (grab sample)	ND
6. Mercury (24 hour composite sample)	0.3
7. Asbestos	not sampled

(13) Salt water intake. 90% of total intake flow.

(14) Estimated value.

D. Wastewater treatment system influent

1. Volatile organics (grab samples)

benzene	110.0
1,2-dichloroethane	7.2
1,1,1-trichloroethane	7.8
1,1-dichloroethane	0.2
chloroform	3.5
ethyl benzene	4.4
methyl chloride	3.4
toluene	250.0

2. Semivolatile organics (24 hour composite samples)

naphthalene	106
phenanthrene	72
2,4-dimethylphenol	460
phenol	140

3. Metals (24 hour composite samples)

antimony	82.0
beryllium	4.0
cadmium	7.5
chromium	280.0
copper	125.0
lead	140.0
nickel	54.0
zinc	290.0

4. Phenolics (grab sample)	3290
5. Cyanide (grab sample)	ND
6. Mercury (24 hour composite sample)	ND
7. Asbestos	not sampled

E. Waste treatment system effluent

1. Volatile organics (grab samples)

1,2-dichloroethane	2.6
1,1,1-trichloroethane	2.7
chloroform	0.4
ethylbenzene	0.1
methylene chloride	0.7

2. Semivolatile organics (24 hour composite samples)

acenaphthylene	1.4

3. Metals (24 hour composite samples)	
antimony	64
beryllium	40
cadmium	5[14]
chromium	35
copper	18[14]
lead	110
nickel	37
zinc	38
4. Phenolics (grab sample)	34
5. Cyanide (grab sample)	ND
6. Mercury (24 hour composite sample)	ND
7. Asbestos	not sampled

Refinery 132[15]

A. Intake water

1. Volatile organics (grab samples)

1,2-dichloroethane	1.6
1,1,1-trichloroethane	0.8
chloroform	9.4
1,1-dichloroethylene	2.0
methyl chloride	4.7
bromoform	1.1
tetrachloroethylene	8.1
trichloroethylene	19.0

2. Semivolatile organics (grab sample/blank)

1,2-dichlorobenzene	4.8/ND
1,4-dichlorobenzene	0.4/ND
bis(2-ethylhexyl)phthalate	41/38
di-n-butyl phthalate	2.1/4.3
phenol	3.1/ND

3. Metals (grab sample/blank)[14]

beryllium	NA/0.5
chromium	NA/3
lead	NA/9

4. Phenolics (grab sample)	20
5. Cyanide (grab sample)	ND
6. Mercury (grab sample/blank)	NA/0.83
7. Asbestos	not sampled

(15) Fresh and municipally supplied intake waters were not sampled, since they contribute only ten percent of the process water usage. The saltwater intake was sampled.

Influent to the wastewater treatment system consists of the refinery discharge and discharges from two chemical manufacturing plants. Discharges from chemical plant #1, chemical plant #2 and influent to the wastetreatment were sampled. The refinery discharge could not be sampled since it is mixed with chemical plant #2 discharge prior to oil-water separation. Priority pollutants that are attributable to the refinery discharge may be calculated from reported sample concentration and flow values at chemical plant #1 (1.65 MGD), chemical plant #2 (0.97 MGD) and the influent (6.9 MGD) to the treatment system.

B. Chemical manufacturing plant #1 discharge

1. Volatile organics (grab samples)

benzene	48.0
chloropenzene	6.1
1,1,1-trichloroethane	0.9
chloroform	37.0
ethylbenzene	67.0
methyl chloride	3.8
tetrachloroethylene	1.7
toluene	250.0
trichloroethylene	5.9

2. Semivolatile organics (grab samples/blank)

1,2-dichlorobenzene	450/ND
1,4-dichlorobenzene	850/ND
naphthalene	270/ND
di-n-butyl phthalate	9.7/4.3
anthracene	6.9/ND

3. Metals (24 hour composite sample/blank)

antimony	290/ND
beryllium	6/0.9[14]
cadmium	2[14]/0.9[14]
chromium	58/6[14]
copper	55/ND
lead	360/21[14]
nickel	74/ND
silver	15/ND
zinc	1500/ND

4. Phenolics (grab sample)	2480
5. Cyanide (grab sample)	ND
6. Mercury (24 hour composite sample/blank)	1.1
7. Asbestos	not sampled

C. Chemical manufacturing plant #2 discharge

1. Volatile organics (grab samples)

benzene	36.0
chloroform	1.4
toluene	15.0
trichlorethylene	1.3

2. Semivolatile organics (24 hour composite sample/blank,

isophorone	450/ND
bis(2-ethylhexyl)phthalate	170/38
di-n-butyl phthalate	5.1/4.3
anthracene	1.5/ND
2,4-dimethylphenol	215/ND
phenol	10/ND

3. Metals (24 hour composite sample/blank)

antimony	170/ND
beryllium	8/0.8[14]
cadmium	2[14]/ND
chromium	95/3[14]
copper	260/ND
lead	350/3[14]
nickel	140/ND
silver	1.8/ND
zinc	950/ND

4. Phenolics (grab sample) 1000

5. Cyanide (grab sample) ND

6. Mercury (24 hour composite sample/blank) 1.8/ND

7. Asbestos not sampled

D. Wastewater treatment system influent

1. Volatile organics (grab samples)

benzene	1200.0
1,2-dichloroethane	17.0
1,1,1-trichloroethane	4.3
chloroform	26.0
ethylbenzene	320.0
methylene chloride	4.2
toluene	2960.0
trichloroethylene	8.2

2. Semivolatile organics (24 hour composite sample/blank)

1,2,4-trichlorobenzene	1.5/ND
1,4-dichlorobenzene	1230/ND
fluoranthene	4.5/ND
isophorone	230/ND
naphthalene	240/ND
bis(2-ethylhexyl)phthalate	230/38
butyl benzyl phthalate	8/ND
anthracene	61/ND
2,4-dimethylphenol	380/ND
phenol	1150/ND

3. Metals (24 hour composite sample/blank)

antimony	130/ND
beryllium	10/1[14]
chromium	56/6[14]
copper	67/ND
lead	260/20[14]
nickel	55/3[14]
silver	17/ND
zinc	480/ND

4.	Phenolics (grab sample)	23200
5.	Cyanide (grab sample)	50
6.	Mercury (24 hour composite sample/blank)	0.5/0.7
7.	Asbestos	not sampled

E. Wastewater treatment system effluent

1.	Volatile organics (grab samples)	ND
2.	Semivolatile organics (24 hour composite sample/blank)	
	isophorone	270/ND
	bis(2-ethylhexyl)phthalate	75/38
	di-n-butyl phthalate	8.8/4.3
3.	Metals (24 hour composite sample/blank)	
	antimony	98/ND
	beryllium	7/1[14]
	chromium	40/5[14]
	copper	16/ND
	lead	160/40[14]
	nickel	39/3[14]
	silver	1.9/ND
	zinc	140/ND
4.	Phenolics (grab sample)	27
5.	Cyanide (grab sample)	ND
6.	Mercury (24 hour composite sample/blank)	1.2/0.5
7.	Asbestos	not sampled

Refinery 133

A. Intake water (all grab samples)

1. Volatile organics

benzene	L 10
1,1-dichloroethane	L 10
1,1,2,2-tetrachloroethane	L 10
chloroform	L 10
1,1-dichloroethylene	L 10
methylene chloride	L 10
tetrachloroethylene	L 10
toluene	L 10

2. Semivolatile organics NA

3. Metals[14]

cadmium	11
chromium	5
copper	6
zinc	190

4. Phenolics 4.2

5. Cyanide ND

6. Mercury 0.4[14]

7. Asbestos not sampled

B. Wastewater treatment system influent

1. Volatile organics (grab sample/blank)

benzene	220/L 10
chloroform	L 10/ND
1,1-dichloroethylene	L 10/L 10
methylene chloride	L 10/190
toluene	300/L 10

2. Semivolatile organics NA

3. Metals (24 hour composite samples)[14]

antimony	93
cadmium	90
chromium	160
copper	21
lead	110
nickel	38
zinc	420

4. Phenolics (24 hour composite sample) 1790

5. Cyanide (24 hour composite sample) ND

6. Mercury (24 hour composite sample) ND

7. Asbestos not sampled

C. Wastewater treatment system effluent before chlorination

1. Volatile organics (grab sample/blank)

chloroform	L 10/L 10
1,1-dichlorethylene	L 10/L 10
methylene chloride	L 10/470
toluene	L 10/L 10

2. Semivolatile organics not sampled

3. Metals not sampled

4. Phenolics (grab sample) 2.1

5. Cyanide ND

6. Mercury not sampled

7. Asbestos not sampled

D. Wastewater treatment system effluent after chlorination

1. Volatile organics

a. Preserved grab sample/blank

chloroform	L 10/L 10
1,1-dichloroethylene	L 10/L 10
methylene chloride	L 10/310
toluene	L 10/L 10
chlorodibromomethane	L 10/ND

b. Unpreserved grab sample/blank

chloroform	L 10/L 10
1,1-dichloroethylene	L 10/L 10
methylene chloride	L 10/340
toluene	L 10/L 10
chlorodibromomethane	13/ND
bromoform	L 10/ND
dichlorobromomethane	L 10/ND
1,2-dichloroethane	ND/L 10

2. Semivolatile organics NA

3. Metals (24 hour composite samples)[14]	
cadmium	35
chromium	4
copper	6
zinc	200
4. Phenolics (grab sample)	2.1
5. Cyanide (grab sample)	ND
6. Mercury (24 hour composite sample)	0.4
7. Asbestos	not sampled

Refinery 134

A. Intake Water #1 [16]

1. Volatile organics (grab samples)

carbon tetrachloride	0.1
1,2-dichloroethane	1.2
1,1,1-trichloroethane	0.5
1,1-dichloroethylene	0.6

2. Semivolatile organics (grab samples)[17] ND

3. Metals (grab samples)

cadmium	2[14]
chromium	78
copper	250[14]
lead	30[14]
nickel	5[14]
zinc	120[14]

4. Phenolics (grab sample) 7.4

5. Cyanide (grab sample) ND

6. Mercury (grab sample) 0.4

7. Asbestos not sampled

B. Intake Water #2[18]

1. Volatile organics (grab samples)

1,2-dichloroethane	5.2
1,1,1-trichloroethane	2.2
chloroform	0.2
1,1-dichloroethylene	0.5
1,2-dichloropropane	40.0
methylene chloride	1.2
tetrachloroethylene	1.0
toluene	0.1
trichloroethylene	0.4

2. Semivolatile organics (grab samples)

bis(2-ethylhexyl)phthalate	635
di-n-butyl phthalate	23
di-n-octyl phthalate	74

(16) Well water intake.

(17) Sample blanks at Refinery 134 analyzed for all semivolatile organic samples. No parameters detected for sample blank analysis.

(18) River water intake.

3. Metals[14] (grab samples)	
lead	8
nickel	4
zinc	61
4. Phenolics (grab sample)	126
5. Cyanide (grab sample)	ND
6. Mercury (grab sample)	0.4
7. Asbestos	not sampled

C. Wastetreatment system influent

1. Volatile organics (grab sample)	
benzene	11.0
1,2-dichloroethane	5.8
1,1,1-trichloroethane	285.0
chloroform	0.5
1,2-dichloropropane	7.2
methylene chloride	41.0
2. Semivolatile organics (24 hour composite sample)	
naphthalene	260.0
anthracene	30.0
fluorene	13.0
pyrene	2.7
3. Metals (24 hour composite/blank)	
antimony	10[14]/ND
chromium	310/3[14]
copper	73/56[14]
lead	10[14]/ND
nickel	7[14]/ND
zinc	410[14]/9[14]
4. Phenolics (Day 1 grab sample)	3370
5. Cyanide (Day 1 grab sample)	ND
6. Mercury (24 hour composite sample/blank)	0.2/ND
7. Asbestos	not sampled

D. Sand filter effluent

1. Volatile organics (grab samples)	
1,2-dichlorethane	0.6
1,1,1-trichlorethylene	9.7
1,1-dichloroethylene	0.6
ethylbenzene	0.1
methylene chloride	4.0
toluene	0.2

2. Semivolatile organics (24 hour composite samples)

bis(2-ethylhexyl)phthalate	43
di-n-butyl phthalate	210

3. Metals (24 hour composite samples)

chromium	69
copper	22^{14}
nickel	5^{14}
zinc	270^{14}

4. Phenolics (grab sample) 11.6

5. Cyanide (grab sample) ND

6. Mercury (24 hour composite sample) 0.3

7. Asbestos not sampled

E. Wastewater treatment system effluent

1. Volatile organics (grab samples)

1,2-dichloroethane	0.7
1,1,1-trichloroethane	2.0
chloroform	1.3
1,2-dichloropropane	1.3
methylene chloride	7.0
bromoform	0.5
chlorodibromomethane	2.4

2. Semivolatile organics (24 hour composite sample/blank)

bis(2-ethylhexyl)phthalate	38/ND

3. Metals (24 hour composite sample/blank)

chromium	68/7^{14}
copper	9^{14}/57
zinc	270/5^{14}

4. Phenolics (grab sample) 7.4

5. Cyanide (grab sample) ND

6. Mercury (24 hour composite sample/blank) 0.5/ND

7. Asbestos not sampled

Refinery 157

A. Intake water

1. Volatile organics:	not sampled
2. Semivolatile organics:	ND[19]
3. Metals	
antimony	L 100
arsenic	9
beryllium	L 25
cadmium	4
chromium	L 5
copper	17
lead	6
nickel	L 25
selenium	L 5
silver	L 5
thallium	L 100
zinc	237
4. Phenolics	NA
5. Cyanide	NA
6. Mercury	0.2
7. Asbestos	not sampled

B. Bio-oxidation pond influent

1. Volatile organics	not sampled
2. Semivolatile organics[20]	
phenol[21]	G 100
bis(2-ethylhexyl)phthalate	10-100
diethyl phthalate	10-100
dimethyl phthalate	10-100

---

(19) Not detected at 10 ug/l or above (some substances may have somewhat higher or lower detection limits).

(20) Other phenols or cresols (including o-cresol, p-cresol, and three dimethyl phenol or ethyl phenol isomers) which are not among the list of 129 priority pollutants were found in this sample.

(21) Phenol was present in this sample at about 100 mg/l, but is reported as G 100 ug/l in accordance with the analytical protocol.

3. Metals	
antimony	150
arsenic	6
beryllium	L 25
cadmium	3
chromium	15
copper	100
lead	8
nickel	L 25
selenium	950
silver	L 5
thallium	L 100
zinc	267
4. Phenolics	230,000
5. Cyanide	3,500
6. Mercury	L 0.2
7. Asbestos	not sampled

C. Wastetreatment system effluent

1. Volatile organics	not sampled
2. Semivolatile organics	ND
3. Metals	
antimony	L 100
arsenic	28
beryllium	L 25
cadmium	8
chromium	20
copper	12
lead	8
nickel	30
selenium	18
silver	L 5
thallium	100
zinc	242
4. Phenolics	34
5. Cyanide	7.5
6. Mercury	0.2
7. Asbestos	not sampled

Refinery 181

A. Intake water[22] (sample/blank)

1. Volatile Organics

a. Preserved

benzene	L 1/L 1
chloroform	11/1
chlorodibromomethane	8/ND
methylene chloride	2/39
dichlorobromomethane	10/ND

b. Unpreserved

chloroform	48/1
chlorodibromomethane	19/ND
methylene chloride	5/39

B. API Separator #1 effluent water

1. Volatile Organics (sample/blank)

methylene chloride	38/39

C. API Separator #2 effluent water[22]

1. Volatile Organics[23] (sample/blank)

benzene	5330/L 1
toluene	4010/1
ethylbenzene	25/ND
methylene.chloride	527/39

D. API Separator #3 effluent water[22]

1. Volatile organics (sample/blank)

benzene	4650/L 1
toluene	5560/1
ethylbenzene	829/ND
methylene chloride	313/39

E. Untreated Sour/Ammonia water[22]

1. Volatile organics (sample/blank)

benzene	1060000/L 1
toluene	7580000/1
chlorobenzene	741000/ND
ehtylbenzene	831000/ND

(22) Semivolatiles, metals, phenolics, cyanide, mercury, and asbestos not sampled. Preserved blanks at Site A were composited with other unpreserved blanks at sites B, C, D, E, F, G & H.

(23) m/p-xylene and o-xylene concentration reported.

F. Wastewater treatment system influent[22]

1. Volatile organics (sample/blank)

benzene	43800/L 1
toluene	266/1
ethylbenzene	368/ND
methylene chloride	1350/39

G. Wastewater treatment system effluent #1[22]

1. Volatile organics (sample/blank)

benzene	113/L 1
toluene	99/1
ethylbenzene	77/ND
methylene chloride	206/39

H. Wastewater treatment system effluent #2[22]

1. Volatile organics (sample/blank)

benzene	50300/L 1
toluene	3310/1
chloroform	300/1
ethylbenzene	422/ND
methylene chloride	2660/39

I. Final wastewater treatment system effluent[24]

1. Volatile organics (sample/blank)

methylene chloride	9/26

2. Semivolatile organics (sample/blank) ND/ND

3. Metals NA

(24) 69. di-n-octyl phthalate & 99. endrin aldehyde not reported but analyzed as not detected. Blanks at Site I analyzed separately from other sites. Phenolics, cyanide, mercury, and asbestos not sampled.

APPENDIX 3

American Petroleum Institute
Sampling Results

(As extracted from "Analysis of Refinery Wastewaters for the EPA Priority Pollutants," Interim Report, API Publication 4296, May 1978.)

CONCENTRATION OF PRIORITY LIQUID/LIQUID EXTRACTABLE ORGANICS AT REFINERY B, UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER				WASTEWATER FEED TO BIOTREATMENT				FINAL EFFLUENT			
		EPA	RADIAN	COMPANY (6)	OTHER	EPA	RADIAN	COMPANY (6)	OTHER	EPA	RADIAN	COMPANY (6)	OTHER
NAPHTHALENE (8)	6	-	ND(< 1)	D(<5)	-	-	22	300	-	-	ND(< 1)	30	-
ACENAPHTHYLENE (14)	6	-	ND(< 1)	D(<40)	-	-	ND(< 1)	200	-	-	ND(< 1)	D(<10)	-
ACENAPHTHENE (13)	6	-	ND(< 1)	D(<40)	-	-	ND(< 1)	30	-	-	ND(< 1)	D(<10)	-
FLUORENE (17)	6	-	ND(< 1)	ND(< 1)	-	-	2.9	ND(< 1) C	-	-	6	ND(< 3)C	-
PHENANTHRENE/ANTHRACENE (24)	6	-	ND(< 1)H	-	-	-	6.4 H	-	-	-	ND(< 1)H	-	-
PHENANTHRENE (25)	6	-	-	ND(<.08)	-	-	-	2.7 C	-	-	-	ND(< 2)C	-
ANTHRACENE (26)	6	-	-	ND(<.01)	-	-	-	ND(<.01) C	-	-	-	ND(<.01)C	-
DIETHYL PHTHALATE (28)	6	-	5.3	-	-	-	60	-	-	-	ND(< 3)	-	-
FLUORANTHENE (29)	6	-	ND(< 1)	ND(<.02)	-	-	ND(< 1)	3 C	-	-	ND(< 1)	.1 C	-
PYRENE (30)	6	-	ND(< 1)	ND(<.02)	-	-	1	1 C	-	-	1.9	1.1 C	-
DI-N-BUTYL PHTHALATE (31)	6	-	1.4	-	-	-	2.8	-	-	-	2	-	-
CHRYSENE/BENZ(A)ANTHRACENE (35)	6	-	ND(< 1)H	-	-	-	.3 H	-	-	-	5 H	-	-
CHRYSENE (36)	6	-	-	ND(<.01)	-	-	-	.3	-	-	-	2 C	-
BIS(2-ETHYLHEXYL)PHTHALATE (37)	6	-	16	-	-	-	1.8	-	-	-	2.6	-	-
BENZ(A)ANTHRACENE (38)	6	-	-	ND(<.01)	-	-	-	.1 C	-	-	-	.08 C	-
BENZO(A)PYRENE (42)	6	-	ND(< 1)	.04	-	-	ND(< 1)	1 C	-	-	4	.1 C	-
BENZO(G,H,I)PERYLENE (45)	6	-	ND(< 2)	ND(<.07)	-	-	ND(< 2)	2 C	-	-	ND(< 2)	2 C	-
PHENOL (53)	6	-	ND(< 1)	-	-	-	13000	-	-	-	1.9	-	-
2-4-DIMETHYLPHENOL (55)	6	-	ND(< 2)	-	-	-	3000	-	-	-	3.3	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
H - THESE COMPOUNDS ARE INDISTINGUISHABLE IN THIS SAMPLE AS ANALYZED BY THE EPA PROTOCOL
6 - NAPHTHALENE, ACENAPHTHALENE, AND ACENAPHTHENE BY GROB GC METHOD; OTHER SPECIES BY GC-UV METHOD

CONCENTRATION OF PRIORITY VOLATILE ORGANICS AT REFINERY B, UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER EPA	INTAKE WATER RADIAN	INTAKE WATER COMPANY (2)	INTAKE WATER OTHER	WASTEWATER FEED TO BIOTREATMENT EPA	WASTEWATER FEED TO BIOTREATMENT RADIAN	WASTEWATER FEED TO BIOTREATMENT COMPANY (2)	WASTEWATER FEED TO BIOTREATMENT OTHER	FINAL EFFLUENT EPA	FINAL EFFLUENT RADIAN	FINAL EFFLUENT COMPANY (2)	FINAL EFFLUENT OTHER
METHYLENE CHLORIDE	(6)	1	-	-	D(<.3)	-	-	-	D(<.3)	-	-	-	D(<5)	-
		2	-	-	6 C	-	-	-	-	-	-	-	D(<5)	-
		3	-	-	-	-	-	-	D(<.5)C	-	-	-	D(<5)	-
		6	-	19 I	-	-	-	9 I	-	-	-	12 I	-	-
CHLOROFORM	(11)	1	-	-	ND(<1)	-	-	-	9	-	-	-	D(<3)	-
		2	-	-	D(<.5)C	-	-	-	-	-	-	-	D(<3)	-
		3	-	-	-	-	-	-	ND(<1)C	-	-	-	D(<5)	-
		6	-	ND(<.3)	-	-	-	ND(<.3)	-	-	-	ND(<.3)	-	-
1,2-DICHLOROETHANE	(12)	1	-	-	-	-	-	-	D(<.5)E	-	-	-	D(<5)E	-
		2	-	-	D(<.5)E	-	-	-	-	-	-	-	ND(<1)E	-
		3	-	-	-	-	-	-	ND(<1)CE	-	-	-	ND(<1)E	-
		6	-	ND(<5)	-	-	-	ND(<5)	-	-	-	ND(<5)	-	-
TRANS-1,3-DICHLOROPROPENE	(17)	1	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	ND(<1)	-
		2	-	-	ND(<1)	-	-	-	-	-	-	-	ND(<1)	-
		3	-	-	-	-	-	-	ND(<1)	-	-	-	ND(<1)	-
		6	-	ND(<.7)	-	-	-	3	-	-	-	1	-	-
TRICHLOROETHYLENE	(18)	1	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	ND(<1)	-
		2	-	-	ND(<1)	-	-	-	-	-	-	-	ND(<1)	-
		3	-	-	-	-	-	-	ND(<1)	-	-	-	ND(<1)	-
		6	-	D(<1)	-	-	-	2	-	-	-	2	-	-
CIS-1,3-DICHLOROPROPENE	(20)	1	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	ND(<1)	-
		2	-	-	ND(<1)	-	-	-	-	-	-	-	ND(<1)	-
		3	-	-	-	-	-	-	ND(<1)	-	-	-	ND(<1)	-
		6	-	ND(<.7)	-	-	-	20	-	-	-	ND(<.7)	-	-
BENZENE	(22)	6	-	D(<1)I	D(<2)	-	-	53	1000	-	-	D(<1)I	D(<10)	-
TOLUENE	(26)	6	-	1 I	D(<2)	-	-	33	2000	-	-	D(<1)I	D(<10)	-
ETHYLBENZENE	(28)	6	-	D(<1)I	D(<20)	-	-	3	100	-	-	D(<1)I	D(<40)	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X. BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
E - MAXIMUM VALUE. REPORTED VALUE MAY INCLUDE OTHER SPECIES WHICH CONTRIBUTE TO THE MEASURED CONCENTRATION
I - BLANK DATA FOR THIS PARAMETER INDICATES CONTAMINATION
2 - ORGANOHALIDES BY BELLAR GC METHOD; OTHER VOLATILE SPECIES BY GROB GC METHOD

CONCENTRATION OF TRACE ELEMENTS AT REFINERY B, UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
		RADIAN	COMPANY	OTHER HAWKSLEY	RADIAN	COMPANY	OTHER HAWKSLEY	RADIAN	COMPANY	OTHER HAWKSLEY
ZINC	(1) 6	23	10	-	48	12	-	27	10	-
CHROMIUM	(2) 1	-	-	10	-	-	29	-	-	71
	2	-	-	32	-	-	75	-	-	63
	3	-	-	5	-	-	32	-	-	-
	6	3 8	ND(<10)	-	79	50	-	94	50	-
COPPER	(3) 6	65	26	-	62	6	-	52	3	-
LEAD	(4) 6	11	9	-	8	26	-	3	46	-
BERYLLIUM	(5) 6	ND(<1)	ND(<10)	-	ND(<1)	ND(<10)	-	ND(<1)	ND(<10)	-
ANTIMONY	(6) 6	14	ND(<30)	-	37	ND(<30)	-	36	ND(<30)	-
THALLIUM	(7) 6	ND(<2)	-	-	ND(<2)	-	-	ND(<2)	-	-
NICKEL	(8) 6	3 5	ND(<2)	-	4 9	ND(<2)	-	2 1	ND(<2)	-
ARSENIC	(9) 6	ND(<1)	-	-	10	-	-	14	-	-
SELENIUM	(10) 6	4	-	-	9	-	-	74	-	-
SILVER	(11) 6	9	1	-	6 3	3	-	4 2	2	-
CADMIUM	(12) 6	.8	ND(<1)	-	1 3	ND(<1)	-	1 1	ND(<1)	-
MERCURY	(13) 6	.4	-	-	5	-	-	8	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE

CONCENTRATION OF TRACE ELEMENTS AT REFINERY D, UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
			RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1)	6	-	-	-	-	-	-	-	-	-
CHROMIUM	(2)	3	-	ND(<10)	-	-	820	-	-	1110	-
		6	-	-	-	-	-	-	-	-	-
COPPER	(3)	6	-	-	-	-	-	-	-	-	-
LEAD	(4)	6	-	-	-	-	-	-	-	-	-
BERYLLIUM	(5)	6	-	-	-	-	-	-	-	-	-
ANTIMONY	(6)	6	-	-	-	-	-	-	-	-	-
THALLIUM	(7)	6	-	-	-	-	-	-	-	-	-
NICKEL	(8)	6	-	-	-	-	-	-	-	-	-
ARSENIC	(9)	6	-	-	-	-	-	-	-	-	-
SELENIUM	(10)	6	-	-	-	-	-	-	-	-	-
SILVER	(11)	6	-	-	-	-	-	-	-	-	-
CADMIUM	(12)	6	-	-	-	-	-	-	-	-	-
MERCURY	(13)	1	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
3 - EPA DATA ON THIS SAMPLE POINT ALSO OBTAINED FROM ANALYSIS BY EPA REGION V

CONCENTRATION OF PRIORITY VOLATILE ORGANICS AT REFINERY E, UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER RADIAN	INTAKE WATER COMPANY (7)	INTAKE WATER OTHER SPECTRIX	WASTEWATER FEED TO BIOTREATMENT RADIAN	WASTEWATER FEED TO BIOTREATMENT COMPANY (7)	WASTEWATER FEED TO BIOTREATMENT OTHER SPECTRIX	FINAL EFFLUENT RADIAN	FINAL EFFLUENT COMPANY (7)	FINAL EFFLUENT OTHER SPECTRIX
METHYLENE CHLORIDE	(6)	1	-	32 S	-	-	10 S	-	-	44 S	-
		2	-	40 S	-	-	16 S	-	-	35 S	-
		3	-	80 S	-	-	10 S	-	-	10 S	-
		4	-	-	6 Z	-	-	29 CZ	-	-	-
1,1-DICHLOROETHANE	(9)	1	-	4	-	-	D(<1)	-	-	D(<1)	-
		2	-	7 6	-	-	D(<1)	-	-	D(<1)	-
		3	-	4	-	-	D(<1)	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-
CHLOROFORM	(11)	1	-	7	-	-	1 2	-	-	D(<1)	-
		2	-	1 5	-	-	1 5	-	-	D(<1)	-
		3	-	1 6	-	-	1	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-
1,2-DICHLOROETHANE	(12)	1	-	3	-	-	D(<1)	-	-	D(<1)	-
		2	-	3 5	-	-	D(<1)	-	-	D(<1)	-
		3	-	3	-	-	D(<1)	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-
1,1,1-TRICHLOROETHANE	(13)	1	-	1	-	-	1	-	-	D(<1)	-
		2	-	2 2	-	-	D(<1)	-	-	D(<1)	-
		3	-	4	-	-	D(<1)	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	13 C	-	-	-
CARBON TETRACHLORIDE	(14)	1	-	3	-	-	D(<1)	-	-	D(<1)	-
		2	-	2	-	-	D(<1)	-	-	D(<1)	-
		3	-	5	-	-	D(<1)	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	2 CZ	-	-	-
BROMODICHLOROMETHANE	(15)	1	-	3 A	-	-	D(<1)	-	-	D(<1)	-
		2	-	13 A	-	-	D(<1)	-	-	D(<1)	-
		3	-	4 A	-	-	D(<1)	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-
1,2-DICHLOROPROPANE	(16)	1	-	D(<1)	-	-	D(<1)	-	-	D(<1)	
		2	-	1	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	ND(<1)	-	-	40	-	-	5	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-
TRICHLOROETHYLENE	(18)	1	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-
BENZENE	(22)	1	-	[illegible])	-	-	450	-	-	D(<1)	-
		2	-		-	-	350	-	-	D(<1)	-
		3	-	[illegible] E	-	-	480	-	-	D(<1)	-
		4	-		-	-	-	240 C	-	-	-
1,1,2,2-TETRACHLOROETHENE	(24)	1	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-
TOLUENE	(26)	1	-	D(<1)	-	-	330	-	-	D(<1)	-
		2	-	D(<1)	-	-	750	-	-	D(<1)	-
		3	-	D(<1)	-	-	640	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	80 C	-	-	-
ETHYLBENZENE	(28)	1	-	D(<1)	-	-	40	-	-	D(<1)	-
		2	-	D(<1)	-	-	40	-	-	D(<1)	-
		3	-	D(<1)	-	-	30	-	-	D(<1)	-
		4	-	-	ND(<1)	-	-	ND(<1)C	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
A - POSSIBLE IDENTIFICATION
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
E - MAXIMUM VALUE. REPORTED VALUE MAY INCLUDE OTHER SPECIES WHICH CONTRIBUTE TO THE MEASURED CONCENTRATION
S - VALUE CONSIDERED ATYPICAL BY REPORTING LABORATORY
Z - BLANK DATA FOR THIS PARAMETER INDICATES CONTAMINATION
7 - PURGE AND TRAP GC METHOD UTILIZING FID AND HALL DETECTORS

CONCENTRATION OF PRIORITY LIQUID/LIQUID EXTRACTABLE ORGANICS AT REFINERY E5 UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
			RADIAN	COMPANY (B)	OTHER SPECTRIX	RADIAN	COMPANY (B)	OTHER SPECTRIX	RADIAN	COMPANY (B)	OTHER SPECTRIX
1,4-DICHLOROBENZENE	(2)	6	-	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)
1,2-DICHLOROBENZENE	(4)	6	-	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)
NAPHTHALENE	(8)	1	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		6	-	-	-	-	-	ND(<1)	-	-	ND(<1)
ACENAPHTHENE	(1)	1	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		6	-	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)
FLUORENE	(17)	1	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		6	-	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)
PHENANTHRENE/ANTHRACENE	(24)	6	-	-	ND(<1)H	-	-	ND(<1)H	-	-	ND(<1)H
PHENANTHRENE	(25)	1	-	ND(< 5)	-	-	ND(< 5)	-	-	ND(< 5)	-
		3	-	ND(< 5)	-	-	ND(< 5)	-	-	ND(< 5)	-
ANTHRACENE	(26)	1	-	ND(<2)	-	-	ND(<2)	-	-	ND(<2)	-
		3	-	ND(<2)	-	-	ND(<2)	-	-	ND(<2)	-
FLUORANTHENE	(29)	1	-	ND(< 5)	-	-	8 E	-	-	ND(< 5)	-
		3	-	ND(< 5)	-	-	5 E	-	-	ND(< 5)	-
		6	-	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)
PYRENE	(30)	1	-	ND(< 5)	-	-	3 E	-	-	ND(< 5)	-
		3	-	ND(< 5)	-	-	3 E	-	-	ND(< 5)	-
		6	-	-	ND(<1)	-	-	-	-	-	-
DI-N-BUTYL PHTHALATE	(31)	6	-	-	-	-	-	-	-	-	ND(<1)
CHRYSENE	(36)	6	-	-	-	-	-	-	-		-
PHENOL	(33)	1	-	ND(<20)	-	-	3000	-	-	ND(<20)	-
		2	-	ND(<20)	-	-	6000	-	-	ND(<20)	-
		3	-	ND(<20)	-	-	8000	-	-	ND(<20)	
		6	-	-	ND(<1)	-	-	-	-	-	-
2-4-DIMETHYLPHENOL	(35)	6	-	-	ND(<1)	-	-	ND(<1)	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
E - MAXIMUM VALUE. REPORTED VALUE MAY INCLUDE OTHER SPECIES WHICH CONTRIBUTE TO THE MEASURED CONCENTRATION
H - THESE COMPOUNDS ARE INDISTINGUISHABLE IN THIS SAMPLE AS ANALYZED BY THE EPA PROTOCOL
B - PHENOLS AND POLYNUCLEAR AROMATIC HYDROCARBONS ANALYZED BY HPLC METHODS

CONCENTRATION OF TRACE ELEMENTS AT REFINERY E UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
			RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1)	1	-	106	-	-	60	-	-	46	-
		2	-	106	-	-	41	-	-	55	-
		3	-	28	-	-	33	-	-	46	-
		4	-	-	-	-	-	-	-	-	-
CHROMIUM	(2)	1	-	37	-	-	106	-	-	63	-
		2	-	66	-	-	79	-	-	71	-
		3	-	49	-	-	89	-	-	60	-
		4	-	-	-	-	-	-	-	-	-
COPPER	(3)	1	-	47	-	-	ND(<3)	-	-	48	-
		2	-	ND(<3)	-	-	5	-	-	10	-
		3	-	36	-	-	36	-	-	14	-
		4	-	-	-	-	-	-	-	-	-
LEAD	(4)	1	-	30	-	-	37	-	-	28	-
		2	-	17	-	-	26	-	-	30	-
		3	-	19	-	-	20	-	-	18	-
		4	-	-	-	-	-	-	-	-	-
BERYLLIUM	(5)	1	-	1.1	-	-	1	-	-	2	-
		2	-	.8	-	-	.8	-	-	1.2	-
		3	-	.9	-	-	1.9	-	-	2.1	-
		4	-	-	-	-	-	-	-	-	-
ANTIMONY	(6)	1	-	25	-	-	27	-	-	56	-
		2	-	21	-	-	27	-	-	32	-
		3	-	30	-	-	64	-	-	67	-
		4	-	-	-	-	-	-	-	-	-
THALLIUM	(7)	1	-	ND(<3)	-	-	8	-	-	6	-
		2	-	ND(<3)	-	-	6	-	-	8	-
		3	-	ND(<3)	-	-	7	-	-	ND(<3	-
		4	-	-	-	-	-	-	-	-	-
NICKEL	(8)	1	-	58	-	-	44	-	-	82	-
		2	-	53	-	-	67	-	-	69	-
		3	-	70	-	-	80	-	-	66	-
		4	-	-	-	-	-	-	-	-	-
ARSENIC	(9)	1	-	ND(<3)	-	-	ND(<3)	-	-	ND(<3)	-
		2	-	ND(<3)	-	-	ND(<3)	-	-	ND(<3)	-
		3	-	ND(<3)	-	-	ND(<3)	-	-	ND(<3)	-
		4	-	-	-	-	-	-	-	-	-
SELENIUM	(10)	1	-	7	-	-	17	-	-	19	-
		2	-	12	-	-	22	-	-	12	-
		3	-	2	-	-	32	-	-	30	-
		4	-	-	-	-	-	-	-	-	-
SILVER	(11)	1	-	6	-	-	ND(<3)	-	-	174	-
		2	-	ND(<3)	-	-	ND(<3)	-	-	ND(<5)	
		3	-	ND(<3)	-	-	160	-	-	ND(<5)	-
		4	-	-	-	-	-	-	-		-
CADMIUM	(12)	1	-	2	-	-	13	-	-	3	-
		2	-	4	-	-	9	-	-	16	-
		3	-	3	-	-	10	-	-	2	-
		4	-	-	-	-	-	-	3	-	-
MERCURY	(13)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	13	-	-	09	-	-	07	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
3 - EPA DATA ON THIS SAMPLE POINT ALSO OBTAINED FROM ANALYSIS BY EPA REGION V

CONCENTRATION OF PRIORITY VOLATILE ORGANICS AT REFINERY F UG/L

PARAMETER		SAMPLE DATE	MAKEUP WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
			RADIAN	COMPANY (7, 9)	OTHER	RADIAN	COMPANY (7, 9)	OTHER	RADIAN	COMPANY (7, 9)	OTHER
METHYLENE CHLORIDE	(4)	1	-	6	-	-	-	-	-	-	-
		2	-	5	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	5	-	-	-	-	-	-	-
		4	-	-	-	-	-	-	-	-	-
1,1,1-TRICHLOROETHANE	(13)	1	-	55	-	-	-	-	-	-	-
		2	-	58	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	51	-	-	-	-	-	-	-
		4	-	-	-	-	-	-	-	-	-
CARBON TETRACHLORIDE	(14)	2	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		4	-	-	-	-	-	-	-	-	-
BENZENE	(22)	1	-	4	-	-	-	-	-	-	-
		2	-	8	-	-	ND(<1)	-	-	ND(<1)	-
		4	-	-	-	-	-	-	-	-	-
TOLUENE	(26)	1	-	13	-	-	-	-	-	-	-
		2	-	15	-	-	ND(<1)	-	-	ND(<1)	-
		4	-	-	-	-	-	-	-	-	-
ETHYLBENZENE	(28)	1	-	D(<.5)	-	-	-	-	-	-	-
		2	-	D(<.5)	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	6	-	-	-	-	-	-	-
		4	-	-	-	-	-	-	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
I - BLANK DATA FOR THIS PARAMETER INDICATES CONTAMINATION
7 - PURGE AND TRAP GC METHOD UTILIZING FID AND HALL DETECTORS
9 - EPA AND COMPANY SAMPLES WERE COLLECTED AND ANALYZED. DATA IS FROM COMPANY SAMPLES

CONCENTRATION OF PRIORITY LIQUID/LIQUID EXTRACTABLE ORGANICS AT REFINERY F, UG/L

PARAMETER		SAMPLE DATE	MAKEUP WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
			RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
NAPHTHALENE	(8)	6	-	3.6	-	-	ND(<10)	-	-	1	-
ACENAPHTHENE	(15)	6	-	5	-	-	ND(<10)	-	-	ND(<10)	-
PHENANTHRENE/ANTHRACENE	(24)	6	-	146 HC	-	-	4.4 HC	-	-	4 HC	-
FLUORANTHENE	(29)	6	-	3.4 C	-	-	ND(<10)C	-	-	2 C	-
PYRENE	(30)	6	-	65 C	-	-	2.9 C	-	-	5 C	-
CHRYSENE/BENZ(A)ANTHRACENE	(35)	6	-	76 CH	-	-	16 CH	-	-	1.4 CH	-
BIS(2-ETHYLHEXYL)PHTHALATE	(37)	6	-	5 E	-	-	2.2 E	-	-	10 E	-
BENZO(B)/(K)FLUORANTHENE	(39)	6	-	3.2 HC	-	-	9 HC	-	-	2 HC	-
BENZO(A)PYRENE	(42)	6	-	8 CE	-	-	7.8 CE	-	-	9 CE	-
INDENO(1.2.3-C.D)PYRENE	(43)	6	-	4 C	-	-	5 C	-	-	ND(<10)C	-
BENZO(G.H.I)PERYLENE	(45)	6	-	2.5 C	-	-	1.2 C	-	-	ND(<10)C	-
PHENOL	(53)	6	-	4	-	-	6	-	-	39	-
2-4-DIMETHYLPHENOL	(55)	6	-	5 E	-	-	11 E	-	-	8 E	-
P-CHLORO-M-CRESOL	(58)	6	-	ND(<15)	-	-	ND(<15)	-	-	2	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
E - MAXIMUM VALUE. REPORTED VALUE MAY INCLUDE OTHER SPECIES WHICH CONTRIBUTE TO THE MEASURED CONCENTRATION
H - THESE COMPOUNDS ARE INDISTINGUISHABLE IN THIS SAMPLE AS ANALYZED BY THE EPA PROTOCOL

CONCENTRATION OF TRACE ELEMENTS AT REFINERY 5 UG/L

PARAMETER		SAMPLE DATE	MAKEUP WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
			RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1)	1	-	230	-	-	220	-	-	170	-
		2	-	220	-	-	200	-	-	170	-
		3	-	200	-	-	260	-	-	190	-
		4	-	-	-	-	-	-	-	-	-
CHROMIUM	(2)	1	-	33	-	-	23	-	-	14	-
		2	-	47	-	-	33	-	-	11	-
		3	-	38	-	-	38	-	-	20	-
		4	-	-	-	-	-	-	-	-	-
COPPER	(3)	1	-	42	-	-	320	-	-	70	-
		2	-	270	-	-	290	-	-	96	-
		3	-	290	-	-	460	-	-	120	-
		4	-	-	-	-	-	-	-	-	-
LEAD	(4)	1	-	3	-	-	5	-	-	ND(< 1)	-
		2	-	3	-	-	6	-	-	ND(< 1)	-
		3	-	3	-	-	5	-	-	2	-
		4	-	-	-	-	-	-	-	-	-
BERYLLIUM	(5)	1	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		2	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		3	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		4	-	-	-	-	-	-	-	-	-
ANTIMONY	(6)	1	-	6	-	-	11	-	-	11	-
		2	-	6	-	-	6	-	-	8	-
		3	-	6	-	-	6	-	-	9	-
		4	-	-	-	-	-	-	-	-	-
THALLIUM	(7)	1	-	ND(< 1)	-	-	2	-	-	ND(< 1)	-
		2	-	ND(< 1)	-	-	2	-	-	ND(< 1)	-
		3	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		4	-	-	-	-	-	-	-	-	-
NICKEL	(8)	1	-	33	-	-	118	-	-	40	-
		2	-	30	-	-	65	-	-	60	-
		3	-	30	-	-	115	-	-	65	-
		4	-	-	-	-	-	-	-	-	-
ARSENIC	(9)	1	-	10	-	-	27	-	-	20	-
		2	-	10	-	-	22	-	-	15	-
		3	-	18	-	-	20	-	-	14	-
		4	-	-	-	-	-	-	-	-	-
SELENIUM	(10)	1	-	19	-	-	21	-	-	11	-
		2	-	19	-	-	26	-	-	9	-
		3	-	19	-	-	30	-	-	14	-
		4	-	-	-	-	-	-	-	-	-
SILVER	(11)	1	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		2	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		3	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		4	-	-	-	-	-	-	-	-	-
CADMIUM	(12)	1	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		2	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		3	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		4	-	-	-	-	-	-	-	-	-
MERCURY	(13)	1	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		2	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-
		3	-	ND(< 1)	-	-	ND(< 1)	-	-	ND(< 1)	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
1 - CONCENTRATION REPORTED AS 0.0
2 - EPA DATA ON THIS SAMPLE POINT ALSO OBTAINED FROM ANALYSIS BY EPA REGION V

CONCENTRATION OF TRACE ELEMENTS AT REFINERY J, UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT (R1)			WASTEWATER FEED TO BIOTREATMENT (R2)		
			RADIAN	COMPANY (11)	OTHER	RADIAN	COMPANY (11)	OTHER	RADIAN	COMPANY (11)	OTHER
ZINC	(1)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
CHROMIUM	(2)	1	-	-	-	-	940	-	-	-	-
		2	-	-	-	-	940	-	-	-	-
		3	-	-	-	-	1300	-	-	-	-
		6	-	ND(30)	-	-	-	-	-	-	-
COPPER	(3)	6	-	-	-	-	-	-	-	-	-
LEAD	(4)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
BERYLLIUM	(5)	6	-	-	-	-	-	-	-	-	-
ANTIMONY	(6)	6	-	-	-	-	-	-	-	-	-
THALLIUM	(7)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
NICKEL	(8)	6	-	-	-	-	-	-	-	-	-
ARSENIC	(9)	6	-	-	-	-	-	-	-	-	-
SELENIUM	(10)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
SILVER	(11)	6	-	-	-	-	-	-	-	-	-
CADMIUM	(12)	6	-	-	-	-	-	-	-	-	-
MERCURY	(13)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-

B(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
4 - PHENOLICS AND CYANIDE DATA FROM RSKERL
11 - COMPOSITE OF 3 API SEPARATORS AND BIO POND INLET

(CONTINUED) CONCENTRATION OF TRACE ELEMENTS AT REFINERY J, UG/L

PARAMETER		SAMPLE DATE	WASTEWATER FEED TO BIOTREATMENT (R3)			WASTEWATER FEED TO BIOTREATMENT (R4)			WASTEWATER FEED TO BIOTREATMENT (R5)		
			RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
CHROMIUM	(2)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
COPPER	(3)	6	-	-	-	-	-	-	-	-	-
LEAD	(4)	6	-	-	-	-	-	-	-	-	-
BERYLLIUM	(5)	6	-	-	-	-	-	-	-	-	-
ANTIMONY	(6)	6	-	-	-	-	-	-	-	-	-
THALLIUM	(7)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
NICKEL	(8)	6	-	-	-	-	-	-	-	-	-
ARSENIC	(9)	6	-	-	-	-	-	-	-	-	-
SELENIUM	(10)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-
		6	-	-	-	-	-	-	-	-	-
SILVER	(11)	6	-	-	-	-	-	-	-	-	-
CADMIUM	(12)	6	-	-	-	-	-	-	-	-	-
MERCURY	(13)	1	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE

CONTINUED: CONCENTRATION OF TRACE ELEMENTS AT REFINERY J, UG/L

PARAMETER		SAMPLE DATE	WASTEWATER FEED TO BIOTREATMENT (R6)			FINAL EFFLUENT		
			RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1)	6	-	-	-	-	-	-
CHROMIUM	(2)	1	-	-	-	-	-	-
		2	-	-	-	-	-	-
		3	-	-	-	-	-	-
		6	-	-	-	-	-	-
COPPER	(3)	6	-	-	-	-	120	-
LEAD	(4)	6	-	-	-	-	-	-
BERYLLIUM	(5)	6	-	-	-	-	-	-
ANTIMONY	(6)	6	-	-	-	-	-	-
THALLIUM	(7)	1	-	-	-	-	-	-
		2	-	-	-	-	-	-
		3	-	-	-	-	-	-
		6	-	-	-	-	-	-
NICKEL	(8)	6	-	-	-	-	-	-
ARSENIC	(9)	6	-	-	-	-	-	-
SELENIUM	(10)	1	-	-	-	-	-	-
		2	-	-	-	-	-	-
		3	-	-	-	-	-	-
		6	-	-	-	-	-	-
SILVER	(11)	6	-	-	-	-	-	-
CADMIUM	(12)	6	-	-	-	-	-	-
MERCURY	(13)	1	-	-	-	-	-	-
		2	-	-	-	-	-	-
		3	-	-	-	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
# - PHENOLICS AND CYANIDE DATA FROM RSKERL

CONCENTRATION OF PRIORITY VOLATILE ORGANICS AT REFINERY K, UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
		RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
METHYLENE CHLORIDE	(6) 6	19	-	-	4 9	-	-	8	-	-
CHLOROFORM	(11) 6	1	-	-	ND(< 3)	-	-	ND(< 3)	-	-
1, 1, 1-TRICHLOROETHANE	(13) 6	1	-	-	1 8	-	-	ND(< 3)	-	-
TRICHLOROETHYLENE	(18) 6	1	-	-	D(<1)	-	-	D(<1)	-	-
BENZENE	(22) 6	D(<1)	-	-	31000	-	-	D(<1)	-	-
1, 1, 2, 2-TETRACHLOROETHENE	(24) 6	1	-	-	ND(< 4)	-	-	ND(< 4)	-	-
TOLUENE	(26) 6	D(<1)	-	-	44000	-	-	D(<1)	-	-
ETHYLBENZENE	(28) 6	D(<1)	-	-	ND(< 5)	-	-	ND(< 5)	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED.
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE

CONCENTRATION OF PRIORITY LIQUID/LIQUID EXTRACTABLE ORGANICS AT REFINERY 11, UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
		RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
NAPHTHALENE	(8) 6	ND(< 1)	-	-	240	-	-	ND(< 1)	-	-
FLUORENE	(17) 6	ND(< 1)	-	-	21	-	-	ND(< 1)	-	-
PHENANTHRENE/ANTHRACENE	(24) 6	ND(< 1)H	-	-	69 H	-	-	ND(< 1)H	-	-
DIETHYL PHTHALATE	(28) 6	2 9	-	-	16	-	-	4 3	-	-
FLUORANTHENE	(29) 6	ND(< 1)	-	-	3 9	-	-	ND(< 1)	-	-
PYRENE	(30) 6	2	-	-	3 4	-	-	ND(< 1)	-	-
DI-N-BUTYL PHTHALATE	(31) 6	2 2	-	-	ND(< 1)	-	-	D(<1)	-	-
CHRYSENE/BENZ(A)ANTHRACENE	(35) 6	ND(< 1)H	-	-	1 8 H	-	-	ND(< 1)H	-	-
BIS(2-ETHYLHEXYL)PHTHALATE	(37) 6	D(<1)	-	-	ND(< 1)	-	-	ND(< 1)	-	-
PHENOL	(33) 6	ND(< 1)	-	-	30	-	-	ND(< 1)	-	-
2-4-DIMETHYLPHENOL	(33) 6	ND(< 2)	-	-	80	-	-	2 2	-	-
2, 4-DICHLOROPHENOL	(57) 6	D(<1)	-	-	ND(< 1)	-	-	ND(< 1)	-	-
4, 6-DINITRO-O-CRESOL	(62) 6	D(<1)	-	-	ND(< 6)	-	-	D(<1)	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED.
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE.
H - THESE COMPOUNDS ARE INDISTINGUISHABLE IN THIS SAMPLE AS ANALYZED BY THE EPA PROTOCOL.

CONCENTRATION OF TRACE ELEMENTS AT REFINERY K_J UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
		RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1) 6	-	10	-	-	1300	-	-	30	-
CHROMIUM	(2) 6	-	2	-	-	1100	-	-	220	-
COPPER	(3) 6	-	ND(<20)	-	-	ND(<20)	-	-	ND(<20)	-
LEAD	(4) 6	-	20	-	-	75	-	-	10	-
BERYLLIUM	(5) 6	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
ANTIMONY	(6) 6	-	ND(<50)	-	-	ND(<50)	-	-	ND(<50)	-
THALLIUM	(7) 6	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
NICKEL	(8) 6	-	2	-	-	52	-	-	9	-
ARSENIC	(9) 6	-	22	-	-	50	-	-	70	-
SELENIUM	(10) 6	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
SILVER	(11) 6	-	ND(<5)	-	-	ND(<5)	-	-	ND(<5)	-
CADMIUM	(12) 6	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
MERCURY	(13) 6	-	3	-	-	5	-	-	3	-

B(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X.
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE

CONCENTRATION OF PRIORITY VOLATILE ORGANICS AT REFINERY N, UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT (B)			WASTEWATER FEED TO BIOTREATMENT (C)		
			RADIAN	COMPANY (2)	OTHER	RADIAN	COMPANY (2)	OTHER	RADIAN	COMPANY (2)	OTHER
CHLOROMETHANE	(1)	1	-	ND(<1)	-	ND(<10)	ND(<1)	-	ND(<10)	-	-
		2	-	ND(<1)	-	-	ND(<1)	-	ND(<10)	-	-
		3	-	D(< 3)	-	ND(<10)	ND(<1)	-	ND(<10)	-	-
		4	ND(<10)	-	-	-	-	-	ND(<10)	17000	-
BROMOMETHANE	(3)	1	-	ND(<1)	-	ND(<5)	ND(<1)	-	ND(<5)	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	ND(<5)	ND(<1)	-
		3	-	ND(<1)	-	ND(<5)	ND(<1)	-	ND(<5)	ND(<1)	-
		4	ND(<5)	-	-	-	-	-	1A ND(<5)	-	-
METHYLENE CHLORIDE	(6)	1	-	6 CE	-	30	1 CE	-	130	D(<1)	-
		2	-	4 E	-	-	1	-	190	D(<1)C	-
		3	-	4 E	-	300	9 CE	-	60	5	-
		4	10	-	-	-	-	-	12 160	-	-
1,1-DICHLOROETHYLENE	(8)	1	-	ND(<1)	-	ND(<1)	ND(<1)	-	ND(<1)	-	-
		2	-	ND(<1)	-	-	ND(<1)	-	1C	ND(<1)	-
		3	-	ND(<1)	-	ND(<1)	ND(<1)	-	ND(<1)	ND(<1)	-
		4	ND(<1)	-	-	-	-	-	ND(<1)	ND(<1)	-
CHLOROFORM	(11)	1	-	ND(<1)	-	ND(< 3)	22 C	-	9	14	-
		2	-	ND(<1)	-	-	17	-	10	7 C	-
		3	-	ND(<1)	-	30	21 C	-	6	9	-
		4	ND(< 3)	-	-	-	-	-	6	-	-
1,2-DICHLOROETHANE	(12)	1	-	ND(<1)E	-	ND(<5)	14 CE	-	ND(<5)	ND(<1)E	-
		2	-	ND(<1)E	-	-	9 E	-	ND(<5)	ND(<1)E	-
		3	-	ND(<1)E	-	30	51 CE	-	ND(<5)	6 E	-
		4	ND(<5)	-	-	-	-	-	ND(<5)	-	-
1,1,1-TRICHLOROETHANE	(13)	1	-	ND(<1)	-	ND(< 3)	ND(<1)	-	ND(< 3)	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	10	ND(<1)	-
		3	-	ND(<1)	-	10	ND(<1)	-	6	ND(<1)	-
		4	2	-	-	-	-	-	ND(< 3)	-	-
1,2-DICHLOROPROPANE	(16)	1	-	ND(<1)	-	ND(< 4)	ND(<1)	-	ND(< 4)	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	ND(< 4)	ND(<1)	-
		3	-	ND(<1)	-	ND(< 4)	ND(<1)	-	ND(< 4)	ND(<1)	-
		4	ND(< 4)	-	-	ND(< 4)	-	-	ND(< 4)	-	-
TRICHLOROETHYLENE	(18)	1	-	ND(<1)	-	ND(< 2)	ND(<1)	-	ND(< 2)	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	ND(< 2)	ND(<1)	-
		3	-	ND(<1)	-	2	ND(<1)	-	2	ND(<1)	-
		4	ND(< 2)	-	-	-	-	-	D(<1)	-	-
DIBROMOCHLOROMETHANE	(19)	1	-	ND(<1)	-	ND(< 5)	ND(<1)	-	ND(< 5)	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	ND(< 5)	ND(<1)	-
		3	-	ND(<1)	-	ND(< 5)	ND(<1)	-	ND(< 5)	ND(<1)	-
		4	ND(< 5)	-	-	-	-	-	-	-	-
BENZENE	(20)	1	-	-	-	30	-	-	50	-	-
		2	-	-	-	-	-	-	40	-	-
		3	-	-	-	30	-	-	10	-	-
		4	1	3	-	-	5000 C	-	20	4000 C	-
1,1,2,2-TETRACHLOROETHENE	(24)	1	-	ND(<1)	-	ND(< 4)	2 C	-	ND(< 4)	ND(<1)	-
		2	-	ND(<1)	-	-	1	-	ND(< 4)	ND(<1)	-
		3	-	ND(<1)	-	ND(< 4)	4 C	-	ND(< 4)	D(< 5)	-
		4	ND(< 4)	-	-	-	-	-	ND(< 4)	-	-
1,1,2,2-TETRACHLOROETHANE	(23)	1	-	ND(<1)	-	ND(< 3)	ND(<1)	-	ND(< 5)	ND(<1)	-
		2	-	ND(<1)	-	-	ND(<1)	-	ND(< 5)	ND(<1)	-
		3	-	ND(<1)	-	2	ND(<1)	-	2	ND(<1)	-
		4	ND(< 5)	-	-	-	-	-	ND(< 5)	-	-
TOLUENE	(26)	1	-	-	-	130	-	-	40	-	-
		2	-	-	-	-	-	-	110	-	-
		3	-	-	-	50	-	-	50	-	-
		4	6	3	-	-	9000 C	-	50	7000 C	-
ETHYLBENZENE	(28)	1	-	-	-	70	-	-	10	-	-
		2	-	-	-	-	-	-	60	-	-
		3	-	-	-	100	-	-	1	-	-
		4	2	D(<2)	-	-	70 C	-	30	D(<70)C	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
A - POSSIBLE IDENTIFICATION
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
E - MAXIMUM VALUE. REPORTED VALUE MAY INCLUDE OTHER SPECIES WHICH CONTRIBUTE TO THE MEASURED CONCENTRATION
I - BLANK DATA FOR THIS PARAMETER INDICATES CONTAMINATION
2 - ORGANOHALIDES BY BELLAR GC METHOD. OTHER VOLATILE SPECIES BY GROB GC METHOD

(CONTINUED) CONCENTRATION OF PRIORITY VOLATILE ORGANICS AT REFINERY N UG/L

PARAMETER		SAMPLE DATE	FINAL EFFLUENT		
			RADIAN	COMPANY (2)	OTHER
CHLOROMETHANE	(1)	1	ND(<10)	D(< 5)	-
		2	ND(<10)	ND(<1)	-
		3	ND(<10)	ND(<1)	-
		4	-	-	-
BROMOMETHANE	(3)	1	ND(<5)	ND(<1)	-
		2	ND(<5)	ND(<1)	-
		3	ND(<5)	ND(<1)	-
		4	-	-	-
METHYLENE CHLORIDE	(6)	1	D(<5)	1 CE	-
		2	D(<5)	6 E	-
		3	D(<5)	5 E	-
		4	-	-	-
1,1-DICHLOROETHYLENE	(8)	1	10	ND(<1)	-
		2	ND(<1)	ND(<1)	-
		3	D(<1)	1	-
		4	-	-	-
CHLOROFORM	(11)	1	ND(< 3)	D(<1)C	-
		2	ND(< 3)	D(< 5)	-
		3	ND(< 3)	D(< 5)	-
		4	-	-	-
1,2-DICHLOROETHANE	(12)	1	ND(<5)	D(< 5)E	-
		2	ND(<5)	D(< 5)E	-
		3	ND(<5)	D(< 5)E	-
		4	-	-	-
1,1,1-TRICHLOROETHANE	(13)	1	3	ND(<1)	-
		2	2	ND(<1)	-
		3	3	ND(<1)	-
		4	-	-	-
1,2-DICHLOROPROPANE	(16)	1	ND(< 4)	ND(<1)	-
		2	ND(< 4)	ND(<1)	-
		3	ND(< 4)	ND(<1)	-
		4	-	-	-
TRICHLOROETHYLENE	(18)	1	1	ND(<1)	-
		2	3	ND(<1)	-
		3	ND(< 2)	ND(<1)	-
		4	-	-	-
DIBROMOCHLOROMETHANE	(19)	1	ND(< 3)	ND(<1)	-
		2	ND(< 3)	ND(<1)	-
		3	ND(< 3)	ND(<1)	-
		4	-	-	-
BENZENE	(22)	1	1	-	-
		2	1	-	-
		3	30	-	-
		4	-	3 C	-
1,1,2,2-TETRACHLOROETHENE	(24)	1	ND(< 4)	ND(<1)	-
		2	ND(< 4)	ND(<1)	-
		3	ND(< 4)	ND(<1)	-
		4	-	-	-
1,1,2,2-TETRACHLOROETHANE	(25)	1	ND(< 3)	ND(<1)	-
		2	ND(< 3)	ND(<1)	-
		3	ND(< 3)	ND(<1)	-
		4	-	-	-
TOLUENE	(26)	1	3	-	-
		2	3	-	-
		3	60	-	-
		4	-	10 C	-
ETHYLBENZENE	(28)	1	1	-	-
		2	1	-	-
		3	20	-	-
		4	-	D(<5)C	-

D(<X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
D(>X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
E - MAXIMUM VALUE. REPORTED VALUE MAY INCLUDE OTHER SPECIES WHICH CONTRIBUTE TO THE MEASURED CONCENTRATION
1 - BLANK DATA FOR THIS PARAMETER INDICATES CONTAMINATION
2 - ORGANOHALIDES BY BELLAR GC METHOD. OTHER VOLATILE SPECIES BY GROB GC METHOD

CONCENTRATION OF PRIORITY LIQUID/LIQUID EXTRACTABLE ORGANICS AT REFINERY N_1 UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT (R1)			WASTEWATER FEED TO BIOTREATMENT (C1)		
		RADIAN	COMPANY (6)	OTHER	RADIAN	COMPANY (6)	OTHER	RADIAN	COMPANY (6)	OTHER
NAPHTHALENE	(8) 6	ND(< 1)	D(<2)	-	430	400 C	-	230	D(<50)	-
ACENAPHTHYLENE	(14) 6	ND(< 1)	D(<2)	-	ND(< 1)	D(<30)	-	ND(< 1)	D(<40)	-
ACENAPHTHENE	(15) 6	ND(< 1)	D(<2)	-	9	200	-	ND(< 1)	D(<40)	-
FLUORENE	(17) 6	ND(< 1)	ND(< 4)	-	30	7 C	-	ND(< 1)	ND(< 4)	-
PHENANTHRENE/ANTHRACENE	(24) 6	3 H	-	-	110 H	-	-	2 H	-	-
PHENANTHRENE	(25) 6	-	ND(< 2)	-	-	28 C	-	-	ND(< 01)	-
ANTHRACENE	(26) 6	-	ND(< 02)	-	-	1 C	-	-	ND(< 2)	-
DIETHYL PHTHALATE	(28) 6	20	-	-	2	-	-	ND(< 4)	-	-
FLUORANTHENE	(29) 6	ND(< 1)	ND(< 04)	-	1	1 7 C	-	2	04	-
PYRENE	(30) 6	2	ND(< 03)	-	3	4 1 C	-	D(< 1)	06	-
DI-N-BUTYL PHTHALATE	(31) 6	20	-	-	10	-	-	45	-	-
BUTYL BENZYL PHTHALATE	(34) 6	2	-	-	ND(< 1)	-	-	6	-	-
CHRYSENE	(36) 6	3	ND(< 02)	-	9	2 C	-	ND(< 1)	ND(< 02)	-
BIS(2-ETHYLHEXYL)PHTHALATE	(37) 6	8	-	-	ND(< 1)	-	-	6	-	-
BENZ(A)ANTHRACENE	(38) 6	1	ND(< 01)	-	ND(< 2)	1 4 C	-	ND(< 1)	ND(< 04)	-
BENZO(B)/(K)FLUORANTHENE	(39) 6	ND(< 2)	-	-	ND(< 2)	-	-	ND(< 2)	-	-
BENZO(B)FLUORANTHENE	(40) 6	-	ND(< 06)	-	-	3 C	-	-	ND(< 09)	-
BENZO(K)FLUORANTHENE	(41) 6	-	ND(< 1)	-	-	3 C	-	-	ND(< 3)	-
BENZO(A)PYRENE	(42) 6	ND(< 1)	07	-	ND(< 1)	8 C	-	ND(< 1)	02	-
INDENO(1,2,3-C,D)PYRENE	(43) 6	ND(< 2)	ND(< 01)	-	ND(< 2)	02 C	-	ND(< 2)	ND(< 02)	-
DIBENZO(A,H)ANTHRACENE	(44) 6	ND(< 3)	ND(< 02)	-	ND(< 3)	07 C	-	ND(< 2)	ND(< 03)	-
BENZO(G,H,I)PERYLENE	(45) 6	ND(< 2)	ND(< 1)	-	ND(< 2)	4 C	-	ND(< 2)	ND(< 2)	-
PHENOL	(53) 6	ND(< 1)	-	-	1300	-	-	13	-	-
2-CHLOROPHENOL	(54) 6	ND(< 1)	-	-	ND(< 1)	-	-	1	-	-
2-4-DIMETHYLPHENOL	(55) 6	ND(< 2)	-	-	480	-	-	8	-	-
2-NITROPHENOL	(56) 6	D(<1)	-	-	ND(< 2)	-	-	ND(< 3)	-	-
2,4-DICHLOROPHENOL	(57) 6	ND(< 1)	-	-	ND(< 1)	-	-	D(<1)	-	-
P-CHLORO-M-CRESOL	(58) 6	ND(< 1)	-	-	ND(< 1)	-	-	D(<1)	-	-
4-NITROPHENOL	(61) 6	4	-	-	ND(< 3)	-	-	ND(< 3)	-	-
4,6-DINITRO-O-CRESOL	(62) 6	D(<1)	-	-	ND(< 6)	-	-	ND(< 3)	-	-
PENTACHLOROPHENOL	(63) 6	D(<1)	-	-	ND(< 4)	-	-	D(<1)	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X) - COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
H - THESE COMPOUNDS ARE INDISTINGUISHABLE IN THIS SAMPLE AS ANALYZED BY THE EPA PROTOCOL
6 - NAPHTHALENE, ACENAPHTHALENE, AND ACENAPHTHENE BY GROB GC METHOD. OTHER SPECIES BY GC-UV METHOD

(CONTINUED) CONCENTRATION OF PRIORITY LIQUID/LIQUID EXTRACTABLE ORGANICS AT REFINERY N, UG/L

PARAMETER	SAMPLE DATE	FINAL EFFLUENT RADIAN	COMPANY (6)	OTHER
NAPHTHALENE	(8) 6	ND(< 1)	4	-
ACENAPHTHYLENE	(14) 6	ND(< 1)	D(<10)	-
ACENAPHTHENE	(13) 6	ND(< 1)	40	-
FLUORENE	(17) 6	ND(< 1)	ND(< 4)	-
PHENANTHRENE/ANTHRACENE	(24) 6	ND(< 1)H	-	-
PHENANTHRENE	(25) 6	-	ND(< 3)	-
ANTHRACENE	(26) 6	-	ND(< 02)	-
DIETHYL PHTHALATE	(28) 6	7	-	-
FLUORANTHENE	(29) 6	ND(< 1)	3	-
PYRENE	(30) 6	D(< 1)	1	-
DI-N-BUTYL PHTHALATE	(31) 6	10	-	-
BUTYL BENZYL PHTHALATE	(34) 6	ND(< 1)	-	-
CHRYSENE	(36) 6	ND(< 1)	ND(< 01)	-
BIS(2-ETHYLHEXYL)PHTHALATE	(37) 6	2	-	-
BENZ(A)ANTHRACENE	(38) 6	ND(< 2)	ND(< 05)	-
BENZO(B)/(K)FLUORANTHENE	(39) 6	ND(< 2)	-	-
BENZO(B)FLUORANTHENE	(40) 6	-	ND(< 06)	-
BENZO(K)FLUORANTHENE	(41) 6	-	ND(< 2)	-
BENZO(A)PYRENE	(42) 6	ND(< 1)	ND(< 01)	-
INDENO(1,2,3-C,D)PYRENE	(43) 6	ND(< 2)	ND(< 06)	-
DIBENZO(A,H)ANTHRACENE	(44) 6	ND(< 3)	ND(< 02)	-
BENZO(G,H,I)PERYLENE	(45) 6	ND(< 2)	ND(< 1)	-
PHENOL	(53) 6	ND(< 1)	-	-
2-CHLOROPHENOL	(54) 6	ND(< 1)	-	-
2-4-DIMETHYLPHENOL	(55) 6	ND(< 2)	-	-
2-NITROPHENOL	(56) 6	ND(< 2)	-	-
2,4-DICHLOROPHENOL	(57) 6	ND(< 1)	-	-
P-CHLORO-M-CRESOL	(58) 6	ND(< 1)	-	-
4-NITROPHENOL	(61) 6	ND(< 3)	-	-
4,6-DINITRO-O-CRESOL	(62) 6	ND(< 6)	-	-
PENTACHLOROPHENOL	(63) 6	ND(< 4)	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
A - POSSIBLE IDENTIFICATION
H - THESE COMPOUNDS ARE INDISTINGUISHABLE IN THIS SAMPLE AS ANALYZED BY THE EPA PROTOCOL
6 - NAPHTHALENE, ACENAPHTHALENE, AND ACENAPHTHENE BY GROB GC METHOD. OTHER SPECIES BY GC-UV METHOD

CONCENTRATION OF TRACE ELEMENTS AT REFINERY M UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT (R1)			WASTEWATER FEED TO BIOTREATMENT (C1)		
		RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1) 6	29	-	-	1000	-	-	9600	-	-
CHROMIUM	(2) 1	-	ND(<)8	-	-	900	-	-	700	-
	2	-	10	-	-	120	-	-	600	-
	3	-	ND(<)8	-	-	740	-	-	360	-
	6	1300	-	-	780	-	-	800	-	-
COPPER	(3) 6	35	-	-	39	-	-	26	-	-
LEAD	(4) 6	6 6	-	-	19	-	-	20	-	-
BERYLLIUM	(5) 6	.4	-	-	3	-	-	3	-	-
ANTIMONY	(6) 6	3	-	-	2 6	-	-	4	-	-
THALLIUM	(7) 6	15	-	-	190	-	-	54	-	-
NICKEL	(8) 6	1.2	-	-	31	-	-	1 5	-	-
ARSENIC	(9) 6	15	-	-	29	-	-	21	-	-
SELENIUM	(10) 6	17	-	-	17	-	-	15	-	-
SILVER	(11) 6	1	-	-	2	-	-	3 1	-	-
CADMIUM	(12) 6	3	-	-	4 1	-	-	1 7	-	-
MERCURY	(13) 1	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-
	6	.4	-	-	4	-	-	59	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED, X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
8 - POSSIBLE TYPOGRAPHICAL ERROR IN ORIGINAL DATA
3 - EPA DATA ON THIS SAMPLE POINT ALSO OBTAINED FROM ANALYSIS BY EPA REGION V

(CONTINUED) CONCENTRATION OF TRACE ELEMENTS AT REFINERY N UG/L

PARAMETER	SAMPLE DATE		FINAL EFFLUENT RADIAN	FINAL EFFLUENT COMPANY	FINAL EFFLUENT OTHER
ZINC	(1)	6	55	-	-
CHROMIUM	(2)	1	-	60	-
		2	-	90	-
		3	-	80	-
		6	110	-	-
COPPER	(3)	6	130	-	-
LEAD	(4)	6	6 6	-	-
BERYLLIUM	(5)	6	2	-	-
ANTIMONY	(6)	6	5 3	-	-
THALLIUM	(7)	6	4 8	-	-
NICKEL	(8)	6	3 4	-	-
ARSENIC	(9)	6	22	-	-
SELENIUM	(10)	6	11	-	-
SILVER	(11)	6	1 3	-	-
CADMIUM	(12)	6	1 1	-	-
MERCURY	(13)	1	-	-	-
		2	-	-	-
		3	-	-	-
		6	5	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED, X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
3 - EPA DATA ON THIS SAMPLE POINT ALSO OBTAINED FROM ANALYSIS BY EPA REGION V

CONCENTRATION OF TRAC. ELEMENTS AT REFINERY 9 UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
			RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1)	2	-	80	-	-	120	-	-	40	-
		3	-	10	-	-	140	-	-	10	-
		4	-	-	-	-	-	-	-	-	-
CHROMIUM	(2)	2	-	ND(<10)	-	-	330	-	-	130	-
		3	-	ND(<10)	-	-	330	-	-	130	-
		4	-	-	-	-	-	-	-	-	-
COPPER	(3)	2	-	20	-	-	30	-	-	10	-
		3	-	20	-	-	40	-	-	ND(<10)	-
		4	-	-	-	-	-	-	-	-	-
LEAD	(4)	2	-	10	-	-	40	-	-	20	-
		3	-	ND(<10)	-	-	20	-	-	ND(<10)	-
		4	-	-	-	-	-	-	-	-	-
BERYLLIUM	(5)	4	-	-	-	-	-	-	-	-	-
ANTIMONY	(6)	4	-	-	-	-	-	-	-	-	-
THALLIUM	(7)	4	-	-	-	-	-	-	-	-	-
NICKEL	(8)	2	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
		3	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
		4	-	-	-	-	-	-	-	-	-
ARSENIC	(9)	2	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
		3	-	ND(<10)	-	-	10	-	-	ND(<10)	-
		4	-	-	-	-	-	-	-	-	-
SELENIUM	(10)	2	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
		3	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
		4	-	-	-	-	-	-	-	-	-
SILVER	(11)	2	-	ND(<5)	-	-	ND(<5)	-	-	ND(<5)	-
		3	-	ND(<5)	-	-	ND(<5)	-	-	ND(<5)	-
		4	-	-	-	-	-	-	-	-	-
CADMIUM	(12)	2	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
		3	-	ND(<10)	-	-	ND(<10)	-	-	ND(<10)	-
		4	-	-	-	-	-	-	-	-	-
MERCURY	(13)	2	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		3	-	ND(<1)	-	-	ND(<1)	-	-	ND(<1)	-
		4	-	-	-	-	-	-	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED.
B(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X.
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE.

CONCENTRATION OF PRIORITY LIQUID/LIQUID EXTRACTABLE ORGANICS AT REFINERY 8, UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER				WASTEWATER FEED TO BIOTREATMENT				FINAL EFFLUENT			
		EPA	RADIAN	COMPANY	OTHER EXXON(5)	EPA	RADIAN	COMPANY	OTHER EXXON(5)	EPA	RADIAN	COMPANY	OTHER EXXON(5)
NAPHTHALENE (8)	6	-	ND(< 1)	ND(<1)I	-	-	1100	5200 CI	-	-	ND(< 1)	ND(<1)I	
FLUORENE (17)	6	-	ND(< 1)	ND(<1)	-	-	62	ND(<1)	5 C	-	ND(< 1)	ND(<1)	ND(< 3)
PHENANTHRENE/ANTHRACENE (24)	6	-	ND(< 1)H	ND(<1)	-	-	99 H	ND(<1)	-	-	ND(< 1)	ND(<1)	-
PHENANTHRENE (25)	6	-	-	-	-	-	-	-	32 C	-	-	-	ND(< 2)
ANTHRACENE (26)	6	-	-	-	-	-	-	-	ND(< 03)C	-	-	-	ND(01)
DIETHYL PHTHALATE (28)	6	-	4	ND(<1)	-	-	3 3	ND(<1)	-	-	3	ND(<1)	-
FLUORANTHENE (29)	6	-	ND(< 1)	ND(<1)	ND(< 03)	-	23	ND(<1)	2 C	-	ND(< 1)	ND(<1)	ND(05)
PYRENE (30)	6	-	ND(< 1)	ND(<1)	ND(< 02)	-	6 9	ND(<1)	6 4 C	-	3	ND(<1)	3
DI-N-BUTYL PHTHALATE (31)	6	-	1	ND(<1)	-	-	D(<1)	ND(<1)	-	-	32	ND(<1)	-
CHRYSENE/BENZ(A)ANTHRACENE (35)	6	-	ND(< 1)H	ND(<1)	-	-	13 H	ND(<1)	-	-	1 H	ND(<1)	
CHRYSENE (36)	6	-	-	-	ND(< 01)	-	-	- C	2 6	-	-	-	ND(02)
BIS(2-ETHYLHEXYL)PHTHALATE (37)	6	-	3	ND(<1)	-	-	2 9	ND(<1)	-	-	13	ND(<1)	-
BENZ(A)ANTHRACENE (38)	6	-	-	-	ND(< 01)	-	-	-	1 4 C	-	-	-	01
BENZO(A)PYRENE (42)	6	-	ND(< 1)	ND(<1)	03	-	4 4	ND(<1)	1 1 C	-	4	ND(<1)	03
DIBENZO(A,H)ANTHRACENE (44)	6	-	ND(< 3)	ND(<1)	-	-	ND(< 3)	ND(<1)	4 C	-	ND(< 3)	ND(<1)	ND(< 03)
BENZO(G,H,I)PERYLENE (45)	6	-	ND(< 2)	ND(<1)	ND(< 1)	-	ND(< 2)	ND(<1)	6 C	-	ND(< 2)	ND(<1)	ND(2)
PHENOL (33)	6	-	D(<1)	ND(<1)I	-	-	15000	26000I	-	-	ND(< 1)	ND(<1)I	
2-4-DIMETHYLPHENOL (33)	6	-	ND(< 2)	ND(<1)	-	-	1300	1200	-	-	ND(< 2)	ND(<1)	

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
B(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
H - THESE COMPOUNDS ARE INDISTINGUISHABLE IN THIS SAMPLE AS ANALYZED BY THE EPA PROTOCOL
I - BLANK DATA FOR THIS PARAMETER INDICATES CONTAMINATION
5 - GC-UV METHOD

CONCENTRATION OF PRIORITY VOLATILE ORGANICS AT REFINERY P, UG/L

PARAMETER		SAMPLE DATE	INTAKE WATER				WASTEWATER FEED TO BIOTREATMENT				FINAL EFFLUENT			
			EPA	RADIAN	COMPANY	OTHER	EPA	RADIAN	COMPANY	OTHER	EPA	RADIAN	COMPANY	OTHER
METHYLENE CHLORIDE	(6)	1	-	6 I	-	-	-	20 I	-	-	-	ND(< 2)I	ND(<1)	-
		2	-	9 I	-	-	-	23 I	-	-	-	4 I	ND(<1)	-
		3	-	10 I	-	-	-	49 I	-	-	-	4 I	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
TRANS-1,2-DICHLOROETHYLENE	(10)	1	-	1	-	-	-	ND(< 7)	-	-	-	ND(< 7)	ND(<1)	-
		2	-	4	-	-	-	1	-	-	-	ND(< 7)	ND(<1)	-
		3	-	3	-	-	-	ND(< 7)	-	-	-	ND(< 7)	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
CHLOROFORM	(11)	1	-	29	-	-	-	2	-	-	-	16	ND(<1)	-
		2	-	31	-	-	-	7	-	-	-	14	ND(<1)	-
		3	-	37	-	-	-	3	-	-	-	10	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
1,1,1-TRICHLOROETHANE	(13)	1	-	2	-	-	-	ND(< 3)	-	-	-	ND(< 3)	ND(<1)	-
		2	-	2	-	-	-	ND(< 3)	-	-	-	ND(< 3)	ND(<1)	-
		3	-	ND(< 3)	-	-	-	ND(< 3)	-	-	-	ND(< 3)	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
TRANS-1,3-DICHLOROPROPENE	(17)	1	-	ND(< 7)	-	-	-	ND(< 7)	-	-	-	ND(< 7)	ND(<1)	-
		2	-	ND(< 7)	-	-	-	2	-	-	-	ND(< 7)	ND(<1)	-
		3	-	ND(< 7)	-	-	-	ND(< 7)	-	-	-	ND(< 7)	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
TRICHLOROETHYLENE	(18)	1	-	1	-	-	-	2	-	-	-	D(<1)	ND(<1)	-
		2	-	D(<1)	-	-	-	4	-	-	-	1	ND(<1)	-
		3	-	1	-	-	-	5	-	-	-	D(<1)	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
BENZENE	(22)	1	-	D(<1)	-	-	-	4700	-	-	-	D(<1)	ND(<1)I	-
		2	-	D(<1)	-	-	-	1000	-	-	-	D(<1)	ND(<1)I	-
		3	-	D(<1)	-	-	-	3300	-	-	-	ND(< 5)	ND(<1)I	-
		6	-	-	ND(<1)	-	-	-	8400	-	-	-	-	-
BROMOFORM	(23)	1	-	ND(< 3)	-	-	-	ND(< 3)	-	-	-	ND(< 3)	ND(<1)	-
		2	-	ND(< 3)	-	-	-	D(<1)	-	-	-	ND(< 3)	ND(<1)	-
		3	-	ND(< 3)	-	-	-	D(<1)	-	-	-	ND(< 3)	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
1,1,2,2-TETRACHLOROETHENE	(24)	1	-	ND(< 4)	-	-	-	6	-	-	-	ND(< 4)	ND(<1)	-
		2	-	ND(< 4)	-	-	-	3	-	-	-	ND(< 4)	ND(<1)	-
		3	-	ND(< 4)	-	-	-	6	-	-	-	ND(< 4)	ND(<1)	-
		6	-	-	ND(<1)	-	-	-	ND(<1)	-	-	-	-	-
TOLUENE	(26)	1	-	3	-	-	-	4200	-	-	-	D(<1)	ND(<1)I	-
		2	-	D(<1)	-	-	-	820	-	-	-	D(<1)	ND(<1)I	-
		3	-	D(<1)	-	-	-	2900	-	-	-	D(<1)	ND(<1)I	-
		6	-	-	ND(<1)	-	-	-	8300	-	-	-	-	-
ETHYLBENZENE	(28)	1	-	D(<1)	-	-	-	440	-	-	-	D(<1)	ND(<1)I	-
		2	-	D(<1)	-	-	-	250	-	-	-	D(<1)	ND(<1)I	-
		3	-	D(<1)	-	-	-	460	-	-	-	D(<1)	ND(<1)I	-
		6	-	-	ND(<1)	-	-	-	200 C	-	-	-	-	-

D(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED.
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED. X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE
I - BLANK DATA FOR THIS PARAMETER INDICATES CONTAMINATION

CONCENTRATION OF TRACE ELEMENTS AT REFINERY P, UG/L

PARAMETER	SAMPLE DATE	INTAKE WATER			WASTEWATER FEED TO BIOTREATMENT			FINAL EFFLUENT		
		RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER	RADIAN	COMPANY	OTHER
ZINC	(1) 6	120	120	-	78	70	-	82	67 C	-
CHROMIUM	(2) 6	11	ND(<1)	-	800	690	-	46	28	-
COPPER	(3) 6	68	ND(<1)	-	26	7	-	16	12	-
LEAD	(4) 6	1.2	ND(<1)	-	4	ND(<1)	-	5.3	7	-
BERYLLIUM	(5) 6	ND(<.1)	ND(<1)	-	2.2	1	-	.7	1	-
ANTIMONY	(6) 6	.4	ND(<1)	-	68	240	-	68	190	-
THALLIUM	(7) 6	ND(<.1)	ND(<1)	-	33	1	-	9.5	ND(<1)	-
NICKEL	(8) 6	1	ND(<1)	-	3.6	27	-	3.6	18	-
ARSENIC	(9) 6	18	ND(<1)	-	23	6	-	16	2	-
SELENIUM	(10) 6	15	ND(<1)	-	13	8	-	15	ND(<1)	-
SILVER	(11) 6	1.2	ND(<1)	-	2.3	ND(<1)	-	.8	ND(<1)	-
CADMIUM	(12) 6	.2	ND(<1)	-	6	ND(<1)	-	.8	ND(<1)	-
MERCURY	(13) 6	.3	ND(<1)	-	8	ND(<1)	-	.4	ND(<1)	-

B(X) - COMPOUND WAS DETECTED AT SOME CONCENTRATION LESS THAN X, BUT THE CONCENTRATION COULD NOT BE QUANTIFIED
G(X) - COMPOUND WAS DETECTED AT A LEVEL GREATER THAN X
ND(X)- COMPOUND WAS NOT DETECTED; X EQUALS THE LOWEST LIMIT OF SENSITIVITY OF THE METHOD FOR THAT SAMPLE
C - ONE OF TWO OR MORE REPORTED VALUES FOR THIS SAMPLE

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